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Early Postoperative Complications Following Extensive Lung Surgery

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Abstract

Background: Extensive surgical procedures play a key role in treatment of various lung diseases. Nevertheless, these complex procedures are associated with a high risk of early postoperative complications.

Objective: To evaluate outcomes of the early postoperative period in patients with various lung diseases and determine risk factors for postoperative complications.

Material and methods: We analyzed postoperative complications in 377 patients who underwent extensive lung surgery. The mean age was 45.7±5.2 years. The majority of patients (56.0%) had malignant or benign lung tumors. Lobectomy was the most common type of surgery. Pneumonectomy accounted for 26.5%.

Results: The overall rate of cardiovascular complications was 8.2%. The highest number of complications was observed after right-sided pneumonectomy (21.7%). Respiratory complications after right-sided pneumonectomy accounted for 34.8%. Lobectomy and bilobectomy had lower rates of complications (4.4% and 6.3%, respectively). The highest number of systemic complications was also recorded after right-sided pneumonectomy (23.9%), whereas lobectomy had a lower risk (4.4%). Patients with primary lung tumors had significantly more complications (32.2%) compared with patients without cancer (10.8%). The main risk factors were male gender (odds ratio [OR], 1.6; 95% CI, 1.1-2.2; $P=.032$), age ≥60 years (OR, 1.9; 95% CI, 1.5-2.6; $P=.001$), smoking (OR, 1.7; 95% CI, 1.2-2.5; $P=.019$), C-reactive protein level >3 mg/dL (OR, 1.8; 95% CI, 1.1-2.7; $P=.015$) and forced expiratory volume in the first second of expiration (FEV_1) <60% (OR, 1.5; 95% CI, 1.1-2.2; $P=.042$), surgery duration ≥180 minutes (OR, 1.8; 95% CI, 1.3-2.3; $P=.002$), and anesthesia without additional epidural analgesia (OR, 1.5; 95% CI, 1.2-2.1; $P=.007$).

Conclusions: The complication rate after extensive lung surgery was 22.8%, with the highest rate after right-sided pneumonectomy (4.8%). Respiratory complications predominated (14.1%): hydrothorax/pneumothorax (5.0%), acute respiratory distress syndrome (4.2%), pneumonia (2.9%), and ventilator-associated tracheobronchitis (2.1%). The main risk factors were male gender, age ≥60 years, smoking, FEV_1 <60%, long surgery, no epidural analgesia, and high crystalloid infusion rate.

Keywords: lung surgery, early postoperative period, respiratory complications, cardiovascular complications, systemic complications, risk factors

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Осложнения раннего послеоперационного периода после расширенных хирургических вмешательств на легких

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Резюме

Актуальность: Расширенные хирургические вмешательства играют ключевую роль в лечении различных заболеваний легких, однако эти сложные процедуры связаны с высоким риском ранних послеоперационных осложнений.

Цель: Оценить результаты раннего послеоперационного периода хирургического лечения больных различными заболеваниями легких с определением факторов риска развития послеоперационных осложнений.

Материалы и методы: Представлены результаты анализа послеоперационных осложнений у 377 пациентов, перенесших расширенные операции на легких. Средний возраст составил 45,7±5,2 года. Большая часть пациентов (56,0%) имела злокачественные или доброкачественные опухоли легких. Наиболее часто проводились лобэктомии. Пневмонэктомии составили 26,5%.

Результаты: Общая частота кардиоваскулярных осложнений составила 8,2%. Наибольшее количество наблюдалось после пневмонэктомии справа (21,7%). Респираторные осложнения после пневмонэктомии справа составили 34,8%. Лобэктомии и билобэктомии имели меньшую частоту осложнений (4,4 и 6,3% соответственно). Наибольшее количество системных осложнений зафиксировано также после пневмонэктомии справа (23,9%), тогда как лобэктомии имели меньший риск (4,4%). У пациентов с первичной опухолью легких наблюдалось значительно больше осложнений (32,2%) по сравнению с пациентами без онкологии (10,8%). Основными факторами риска были: мужской пол (ОШ 1,6; 95% ДИ 1,1–2,2, *p*=0,032), возраст ≥60 лет (ОШ 1,9; 95% ДИ 1,5–2,6, *p*=0,001) и курение (ОШ 1,7; 95% ДИ 1,2–2,5, *p*=0,019), СРБ>3 мг/дл (ОШ 1,8, 95% ДИ 1,1–2,7, *p*=0,015) и ОФВ1<60% (ОШ 1,5, 95% ДИ 1,1–2,2, *p*=0,042), продолжительность операции ≥180 мин (ОШ 1,8; 95% ДИ 1,3–2,3, *p*=0,002), проведение анестезии без дополнительной эпидуральной анальгезии (ОШ=1,5; 95% ДИ 1,2-2,1; *p*=0,007).

Заключение: Частота осложнений после расширенных хирургических вмешательств на легких составила 22,8%, с наибольшим количеством после правосторонней пневмонэктомии (4,8%), где респираторные осложнения преобладали (14,1%), включая гидроторакс/пневмоторакс (5,0%), ОРДС (4,2%), пневмонию (2,9%) и трахеобронхит, ассоциированный с искусственной вентиляцией легких (2,1%), а основными факторами риска были мужской пол, возраст ≥60 лет, курение, ОФВ1 < 60%, длительная операция, отсутствие эпидуральной анальгезии и высокая скорость инфузии кристаллоидов.

Ключевые слова: хирургия легких, ранний послеоперационный период, респираторные осложнения, кардиоваскулярные осложнения, системные осложнения, факторы риска

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Introduction

Despite high risk and potential significant early postoperative complications, especially in cases of malignant and benign tumors, extensive lung surgical procedures, such as lobectomy, pneumonectomy, and complex resections, generally demonstrate favorable short-term and long-term outcomes, with a 5-year survival rate of 60% to 70%.[1-3]

Recent studies showed that pneumonectomy has a 5-year overall survival rate of 65.4%. Furthermore, an analysis of 145 patients who underwent pneumonectomy for malignant tumors revealed a 30-day complication rate of 41.4% and a 30-day mortality of 8.3%.[1,2,4] Studies in patients with non–small cell lung cancer demonstrated that pneumonectomy significantly improves both overall and cancer-specific survival compared with nonsurgical treatment.[3]

The early postoperative period (typically the first 30 days after surgery) is a critical time when patients are particularly vulnerable to complications, such as respiratory failure, infections, and cardiovascular disorders. Early detection and effective treatment of these complications are crucial for improving recovery and ensuring the best outcomes for patients undergoing extensive lung surgery.

The main risk factors for complications are cardiovascular comorbidities, the leading cause of complications with an incidence of 54.2%.[2] Emergency hospitalizations and systemic postoperative complications also often contribute to adverse outcomes.[4] Despite the high risks, extensive lung surgical procedures remain a viable option, particularly for certain tumor types and stages. The key to achieving optimal outcomes is careful patient selection and proper management.

Despite significant advancements in surgery, anesthesiology, and postoperative care, the rate of early postoperative complications remains high. This study aims to analyze the most common complications following extensive lung surgery, identify risk factors for postoperative complications, and assess the effectiveness of existing prevention and treatment methods. Understanding these factors is essential for optimizing postoperative care and reducing the complication rate in patients who underwent thoracic surgery.

Methods

We retrospectively analyzed clinical data of 377 patients who underwent extensive surgery for various lung diseases at the Republican Specialized Scientific and Practical Medical Center of Surgery named after Academician V. Vakhidov (Tashkent, Uzbekistan) between January 2009 and December 2022.

The mean age of the patients was 45.7±5.2 years. Of all patients, 46.2% (n=174) were men, and 53.8% (n=203) were women. The majority (56.0%, n=211) had malignant or benign lung tumors. The second most common disease was bronchiectasis (22.8%, n=86), followed by echinococcosis (17.0%, n=64). Bronchial disorders accounted for only 4.2% (n=16).

The most common comorbidity was obesity (15.1%, n=57). Body mass index (BMI) ranged from 14.5 to 34.3 (mean, 25.4±3.6). Coronary artery disease was the second most common condition (12.7%, n=48), followed by diabetes (8.2%, n=31), smoking (6.9%, n=26), and heart failure (2.6%, n=10). Nearly half of the patients had a Charlson Comorbidity Index score of ≥5.

As part of preoperative assessment, all the patients underwent general clinical and laboratory examinations.

All surgical procedures were performed by the same surgical team. The surgery was performed under general anesthesia combined with one-lung ventilation and involved anatomical lung resection (lobectomy, bilobectomy, pneumonectomy) and lymph node dissection (during lung cancer surgery).

Lobectomy was the most common type of surgery. Left-sided lobectomy was performed in 33.4% (n=126) of the patients, and right-sided lobectomy in 30.0% (n=113). Pneumonectomy accounted for a large number of the procedures, with left-sided pneumonectomy (14.3%, n=54) being slightly more common compared with right-sided pneumonectomy (12.2%, n=46). Bilobectomy, though less common, comprised 10.1% (n=38) of all procedures.

Postoperative complications were classified as per *Standards for Definitions and Use of Outcome Measures for Clinical Effectiveness Research in Perioperative Medicine* developed by the joint task force of the European Society of Anaesthesiology (ESA) and the European Society of Intensive Care Medicine (ESICM).[5] The complications were recorded throughout the entire hospital stay and categorized as cardiovascular (arrhythmias, signs of myocardial ischemia, thromboembolism), neurological (stroke, delirium, transient ischemic attack), respiratory (hydrothorax, pneumothorax, pneumonia, acute respiratory distress syndrome [ARDS], ventilator-associated tracheobronchitis), and systemic (bleeding, sepsis, disseminated intravascular coagulation [DIC], multiple organ dysfunction syndrome).

To identify risk factors for postoperative complications, we examined the following:

- Individual and preoperative characteristics of the patients (gender, age, BMI, American Society of Anesthesiologists [ASA] score, smoking history, history of preoperative respiratory infection, forced expiratory volume in the first second of expiration [FEV_1], previous lung surgery, preoperative radiotherapy and/or chemotherapy, preoperative hemoglobin levels, preoperative C-reactive protein [CRP] levels >3 mg/dL, and preoperative blood gas levels);
- Characteristics related to surgery and anesthesia. We analyzed anesthetic management based on specific aspects of surgery, including the use of inhalation anesthetics or total intravenous anesthesia, infusion therapy (intraoperative crystalloid infusion rate ≥6 mL/kg/h, total volume of intraoperative crystalloids and colloids), transfusion therapy (red blood cells and fresh frozen plasma), and the need for intraoperative vasopressor agents. Furthermore, mechanical ventilation settings during one-lung ventilation were analyzed.

Table 1
Patient distribution based on the extent of lung surgery
Таблица 1
Распределение пациентов в зависимости от объема хирургии легкого

Surgery type	Total (n=377)
Right-sided pneumonectomy	46 (12.2%)
Left-sided pneumonectomy	54 (14.3%)
Bilobectomy	38 (10.1%)
Right-sided lobectomy	113 (30.0%)
Left-sided lobectomy	126 (33.4%)

Statistical analysis was performed using SPSS, version 23 (IBM Corp, USA). Nonparametric Mann-Whitney tests were used to compare variables between groups, with statistical significance set at $P<.05$. Multivariate analysis was conducted using logistic regression.

Results

The rate of cardiovascular complications was 8.2% (31 of 377). The highest number of complications was observed after right-sided pneumonectomy (21.7%): high rates of arrhythmias (8.7%; 4 of 46) and stroke (6.5%; 3 of 46) in particular. Lobectomy and bilobectomy showed significantly lower complication rates (Table 2).

Pneumonectomy had the highest number of respiratory complications (34.8% for right-sided pneumonectomy and 29.6% for left-sided pneumonectomy), including hydrothorax/pneumothorax, pneumonia, and ARDS. Bilobectomy and lobectomy showed fewer complications, with lobectomy presenting a significantly lower risk (4.4% for right-sided lobectomy and 6.3% for left-sided lobectomy) (Table 3).

Table 2
Cardiovascular and neurological complications
Таблица 2
Кардиоваскулярные и неврологические осложнения

Surgery type	Stroke	Arrhythmias	Signs of MI	TE	Total
Right-sided pneumonectomy (n=46)	3 (6.5%)	4 (8.7%)	3 (6.5%)	0 (0.0%)	10 (21.7%)
Left-sided pneumonectomy (n=54)	1 (1.9%)	5 (9.3%)	3 (5.6%)	0 (0.0%)	9 (16.7%)
Bilobectomy (n=38)	0 (0.0%)	2 (5.3%)	1 (2.6%)	0 (0.0%)	3 (7.9%)
Right-sided lobectomy (n=113)	0 (0.0%)	3 (2.7%)	0 (0.0%)	1 (0.9%)	4 (3.5%)
Left-sided lobectomy (n=126)	2 (1.6%)	3 (2.4%)	0 (0.0%)	0 (0.0%)	5 (4.0%)
All procedures (n=377)	6 (1.6%)	17 (4.5%)	7 (1.9%)	1 (0.3%)	31 (8.2%)

Note: MI, myocardial ischemia; TE, thromboembolism

Прим.: MI – ишемия миокарда; TE – тромбоэмболия

Table 3
Respiratory complications
Таблица 3
Респираторные осложнения

Surgery type	Hydrothorax/ Pneumothorax	Pneumonia	Tracheobronchitis	ARDS	Total
Right-sided pneumonectomy (n=46)	7 (15.2%)	3 (6.5%)	2 (4.3%)	4 (8.7%)	16 (34.8%)
Left-sided pneumonectomy (n=54)	6 (11.1%)	3 (5.6%)	3 (5.6%)	4 (7.4%)	16 (29.6%)
Bilobectomy (n=38)	3 (7.9%)	2 (5.3%)	1 (2.6%)	3 (7.9%)	8 (21.1%)
Right-sided lobectomy (n=113)	2 (1.8%)	1 (0.9%)	1 (0.9%)	1 (0.9%)	5 (4.4%)
Left-sided lobectomy (n=126)	1 (0.8%)	2 (1.6%)	1 (0.8%)	4 (3.2%)	8 (6.3%)
All procedures (n=377)	19 (5.0%)	11 (2.9%)	8 (2.1%)	16 (4.2%)	53 (14.1%)

Note: ARDS, acute respiratory distress syndrome

Прим.: ARDS – острый респираторный дистресс синдром

Pneumonectomy was also associated with a high risk of systemic complications. The highest number of systemic complications was observed after right-sided pneumonectomy (23.9%). Both right-sided and left-sided lobectomy had significantly fewer systemic complications (4.4% and 3.2%, respectively) compared with pneumonectomy and bilobectomy (Table 4).

Hospital mortality and outcomes of postoperative complications were influenced by several serious factors. Sepsis (2.4%; 9 of 377) resulted from pneumonia, leading to septic shock and multiple organ dysfunction syndrome. DIC (2.1%; 8 of 377) occurred against the massive blood loss, accompanied by microthrombosis and bleeding. As a result of all these complications, mortality reached 3.2% (12 of 377), with severe cases of sepsis, DIC, tracheobronchitis, and ARDS.

A total of 86 patients (22.8%) had early postoperative complications. Significantly more complications were observed in the patients who underwent surgery for primary lung tumors (32.2%; 68 of 211) compared with those without cancer (10.8%; 18 of 148). For this reason, we conducted further statistical analysis of this subgroup.

Findings of univariate analysis comparing the demographic and preoperative clinical characteristics of the patients with and without complications revealed that male gender, age above 60 years, smoking history, history of respiratory infection less than a month before surgery, baseline CRP level >3 mg/dL, and FEV_1 <60% are potential risk factors for complications after extensive lung surgery (Table 5).

Significant intraoperative risk factors included surgery duration exceeding 180 minutes, pneumonectomy, increased intraoperative blood loss, intravenous infusion volumes of crystalloids >6 mL/kg/h, need for intraoperative blood transfusion, anesthesia without additional epidural analgesia, and use of low positive end-expiratory pressure values (<5 cm H_2O) during one-lung ventilation (Table 6).

Table 4
Systemic complications
Таблица 4
Системные осложнения

Surgery type	Bleeding	Sepsis	DIC	MODS	Total
Right-sided pneumonectomy (n=46)	2 (4.3%)	2 (4.3%)	3 (6.5%)	4 (8.7%)	11 (23.9%)
Left-sided pneumonectomy (n=54)	2 (3.7%)	1 (1.9%)	2 (3.7%)	2 (3.7%)	7 (13.0%)
Bilobectomy (n=38)	2 (5.3%)	3 (7.9%)	1 (2.6%)	2 (5.3%)	8 (21.1%)
Right-sided lobectomy (n=113)	0 (0.0%)	1 (0.9%)	2 (1.8%)	2 (1.8%)	5 (4.4%)
Left-sided lobectomy (n=126)	0 (0.0%)	2 (1.6%)	0 (0.0%)	2 (1.6%)	4 (3.2%)
All procedures (n=377)	6 (1.6%)	9 (2.4%)	8 (2.1%)	12 (3.2%)	35 (9.3%)

Note: DIC, disseminated intravascular coagulation; MODS, multiple organ dysfunction syndrome

Прим.: DIC – диссеминированное внутрисосудистое свертывание; MODS – синдром полиорганной недостаточности

Table 5
Univariate analysis of individual preoperative characteristics
Таблица 5
Одномерный анализ индивидуальных предоперационных характеристик

Indicator	No complications (n=143)	With complications (n=68)	*P* value
Individual characteristics			
Male gender	80 (55.9%)	48 (70.6%)	**<.001**
Age (years)	55.4±7.3	59.7±8.2	**.001**
≥ 60 years	38 (26.6%)	22 (32.4%)	**.001**
BMI	25.6±6.1	25.8±5.9	.658
≤19	7 (4.9%)	4 (5.0%)	.549
>30	28 (19.6%)	14 (20.6%)	.959
Smoking	31 (21.7%)	24 (35.3%)	**.007**
ASA score ≥3	102 (71.3%)	53 (77.9%)	.031
Neoadjuvant therapy			
Radiotherapy	17 (11.9%)	9 (13.2%)	.061
Chemotherapy	15 (10.5%)	7 (10.3%)	.627
Preoperative characteristics			
Respiratory infection less than a month before surgery	6 (4.2%)	7 (10.3%)	**.01**
CRP >3 mg/dL	102 (71.3%)	58 (85.3%)	**.004**
Hemoglobin (g/L)	114±3.2	116±3.4	.866
pH	7.42±0.03	7.42±0.,04	.272
PaO_2 (mm Hg)	86.3±9.1	84.4±8.9	.723
$PaCO_2$ (mm Hg)	37.4±4.8	36.8±5.2	.24
FEV_1 <60%	22 (15.4%)	16 (23.5%)	**<.001**

Notes: ASA, American Society of Anesthesiologists; BMI, body mass index; CRP, C-reactive protein; FEV_1, forced expiratory volume in the first second of expiration

Прим.: ASA – American Society of Anesthesiologists; BMI – индекс массы тела; CRP – С-реактивный белок; FEV_1 – объем форсированного выдоха за первую секунду маневра форсированного выдоха

The multivariate logistic regression analysis revealed significant risk factors related to patients: male gender (odds ratio [OR], 1.6; 95% CI, 1.1-2.2; *P*=.032), age ≥60 years (OR, 1.9; 95% CI, 1.5-2.6; *P*=.001), and smoking (OR, 1.7; 95% CI, 1.2-2.5; *P*=.019). Significant preoperative risk factors included CRP levels >3 mg/dL (OR, 1.8; 95% CI, 1.1-2.7; *P*=.015) and FEV_1 <60% (OR, 1.5; 95% CI, 1.1-2.2; *P*=.042). The surgical risk factor, surgery duration ≥180 minutes, (OR, 1.8; 95% CI, 1.3-2.3; *P*=.002) significantly correlated with the occurrence of complications.

Two anesthesia-related risk factors showed significant correlation with complications in the multivariate logistic regression analysis: anesthesia without additional epidural analgesia (OR, 1.5; 95% CI, 1.2-2.1; *P*=.007),

Table 6
Univariate analysis of characteristics related to surgery and anesthesia
Таблица 6
Одномерный анализ характеристик, связанных с хирургическим вмешательством и анестезией

Indicator	No complications (n=143)	With complications (n=68)	*P* value
Characteristics related to surgery			
Surgery duration ≥180 min	26 (18.2%)	25 (36.8%)	**.006**
Pneumonectomy	34 (23.8%)	30 (44.1%)	**.005**
Intraoperative blood loss (mL)	420.6±22.8	534.5±26.7	**.0014**
Characteristics related to anesthesia			
Volume of crystalloid infusion ≥6 mL/kg/h	96 (67.1%)	58 (85.3%)	**.006**
Colloids	14 (9.8%)	8 (11.8%)	.844
Intraoperative vasopressor agents	102 (71.3%)	56 (82.4%)	.085
Intraoperative blood transfusion	4 (2.8%)	8 (11.8%)	**.021**
Intraoperative plasma transfusion	2 (1.4%)	5 (7.4%)	**.025**
Continuous epidural analgesia	96 (67.1%)	33 (48.5%)	**.015**
One-lung ventilation with PEEP ≤5 cm H_2O	64 (44.8%)	44 (64.7%)	**.011**

Note: PEEP, positive end-expiratory pressure

Прим.: PEEP – положительное давление конца выдоха

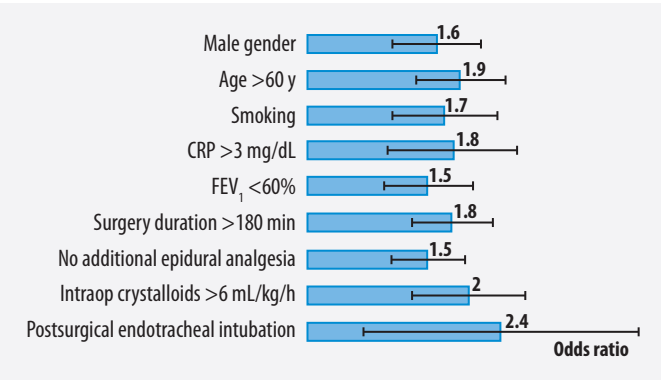

Figure. Multivariate stepwise logistic regression analysis of individual and procedure risk factors for postoperative complications in patients with primary lung tumor lesions (odds ratios and 95% CIs are shown)
Рисунок. Многомерный пошаговый логистический регрессионный анализ индивидуальных и процедурных факторов риска развития послеоперационных осложнений у пациентов с первичным опухолевым поражением легких (показаны ОШ и пределы погрешности согласно 95% ДИ)
Note: CRP, C-reactive protein; FEV_1, forced expiratory volume in the first second of expiration
Прим.: CRP – С-реактивный белок; FEV_1 – объем форсированного выдоха за первую секунду маневра форсированного выдоха

prolonged mechanical ventilation (OR, 2.4; 95% CI, 1.4-4.8; *P*=.001), and intraoperative crystalloid infusion rate >6 mL/kg/h (OR, 2.0; 95% CI, 1.5-2.9; *P*=.001).

Discussion

Preserving maximum amount of lung parenchyma during extensive lung surgery is now a favorable factor for maintaining patient's quality of life, provided that oncological principles of surgery are observed. Most surgeons and intensivists prove it in practice, based on physical examination and imaging methods after surgery. Thus, lung-preserving surgery is currently the surgery of choice when the radicality of surgery can be maintained.[6-9]

Lobectomy is associated with lower morbidity and mortality compared with other major surgical procedures. Studies show that the 30-day mortality rate for lobectomy is significantly lower than those for bilobectomy or pneumonectomy.[10]

Bilobectomy may be required for more extensive tumors but carries higher risks. The 30-day mortality rate of bilobectomy is comparable to left-sided pneumonectomy but significantly worse compared with lobectomy. Furthermore, the overall morbidity for bilobectomy is higher than that after lobectomy.[9]

Pneumonectomy is characterized by a high rate of complications. The 30-day mortality rate is 8.3%, whereas the 90-day mortality rate reaches 17.2%.[2] The main factor increasing the risk of complications is the presence of cardiovascular comorbidities.[2,6]

Although lobectomy generally provides better outcomes, the need for more radical procedures, such as bilobectomy or pneumonectomy, may arise depending on tumor characteristics. This underscores the importance of an individualized approach and choice of a surgical strategy based on the unique disease profile and patient condition.

The prevalence of variables affecting the risk of cardiopulmonary complications has changed over time. Some authors consider age to be an important risk factor for morbidity after lung resection.[8,9,11]

Heart failure development after pneumonectomy is explained by a significant increase in mean pulmonary artery pressure. A strong direct correlation between increased mean pulmonary artery pressure after pneumonectomy and plasma NT-proBNP concentration has been identified.[12]

Atyukov et al (2023) reported that high Charlson Comorbidity Index, surgery via thoracotomy, emphysematous changes, adhesions, and absence of interlobar fissures were independent unfavorable prognostic factors for early postoperative complications.[13]

Such lung surgical procedures as lobectomy, bilobectomy, and pneumonectomy play a key role in treating lung diseases and have varying impacts on postoperative morbidity. Understanding the differences in their outcomes is crucial for preoperative risk assessment and subsequent patient management. Given the complex anatomy of the thorax and the significant physiologic impact of lung tissue resection, postoperative complications can lead to prolonged hospitalization, increased mortality, and poorer long-term treatment outcomes.

Conclusions

Our findings showed that the complication rate after extensive lung surgery was 22.8%, with the highest rate following right-sided pneumonectomy (4.8%). Among these complications, respiratory complications accounted for 14.1%, with hydrothorax/pneumothorax (5.0%), ARDS (4.2%), pneumonia (2.9%), and ventilator-associated tracheobronchitis (2.1%) being the most common.

As indicated by the multivariate logistic regression analysis, the main risk factors for postoperative complications after extensive lung surgery were male gender (OR, 1.6; 95% CI, 1.1-2.2; *P*=.032), age ≥60 years (OR, 1.9; 95% CI, 1.5-2.6; *P*=.001), and smoking (OR, 1.7; 95% CI, 1.2-2.5; *P*=.019), CRP >3 mg/dL (OR, 1.8; 95% CI, 1.1-2.7; *P*=.015) and FEV_1 <60% (OR, 1.5; 95% CI, 1.1-2.2; *P*=.042), surgery duration ≥180 minutes (OR, 1.8; 95% CI, 1.3-2.3; *P*=.002), anesthesia without additional epidural analgesia (OR, 1.5; 95% CI, 1.2-2.1; *P*=.007), prolonged mechanical ventilation (OR, 2.4; 95% CI, 1.4-4.8; *P*=.001), and intraoperative crystalloid infusion rate >6 mL/kg/h (OR, 2.0; 95% CI, 1.5-2.9; *P*=.001).

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