

Applicability and validation of a Clavien-Dindo classification for postoperative complications in lung cancer surgery

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Abstract:

Background: There is no standard scale to evaluate complications after lung cancer surgery. Many surgical fields use the Clavien-Dindo classification for postoperative complications. We adapted the Clavien-Dindo classification by modifying it to reflect the complications that developed in patients who underwent surgery for lung cancer at our clinic. We aimed to demonstrate the applicability and accuracy of this classification.

Methods: A retrospective study involving 802 patients who underwent lung cancer surgery at two sites was conducted between January 2002 and December 2019. Age, gender, surgical method, procedure, complications, and survival times were documented. One hundred eighty patients who experienced complications were assessed using the Clavien-Dindo classification. The correlation between this grading and survival was examined.

Results: Of 802 patients who underwent surgery for lung cancer, 180 patients developed 224 complications. The distribution of complications according to the Clavien-Dindo classification was as follows: Grade I: 46 patients (25.6%); Grade II: 64 patients (35.6%); Grade IIIa: 22 patients (12.2%); Grade IIIb: 12 patients (6.7%); Grade IVa: 10 patients (5.6%); Grade IVb: 10 patients (5.6%); Grade V: 16 patients (8.9%). In the survival analysis, survival decreased significantly with increasing Clavien-Dindo complication grade ($p < 0.001$).

Conclusion: There is no standardized classification of complications after lung cancer resection. We found the Clavien-Dindo classification to be applicable and verifiable for analyzing complications after lung cancer surgery. The effect of the Clavien-Dindo classification on survival underscores the importance of classifying complications after lung cancer surgery. To clarify this important issue, a database should be created, and large-scale multicenter studies should be conducted.

Keywords: Clavien-Dindo classification, lung cancer, postoperative complications, surgery

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INTRODUCTION

Lung cancer is the most prevalent disease responsible for mortality globally (1,2). Tobacco use accounts for 80–90% of all lung cancer cases; however, other hereditary and environmental risk factors also contribute. TNM classification is employed for the staging of lung cancer (3). Surgery is the preferred treatment for early-stage and locally progressed lung cancer when clinically indicated (4,5).

Postoperative complications following lung cancer surgery elevate morbidity and mortality rates (6). Approximately 30–40% of people have problems (6). Classifying postoperative problems and reaching consensus are crucial for their management and prevention. The Clavien-Dindo classification is the predominant system utilized to categorize postoperative problems arising from surgical interventions (7,8). This categorization technique categorizes problems by severity (7,8) (Table 1).

However, there is no standard classification method for classifying complications after lung cancer surgery (6). The European Society of Thoracic Surgeons (ESTS) has developed a classification system, Thoracic Morbidity and Mortality (TM&M), utilizing the ESTS database to categorize complications following lung surgery (6). The European Society of Thoracic Surgeons (ESTS) classified the complications after lung cancer surgery into two groups: minor and major (Table 2). They

classified Grade I-II as minor complications, Grade III-IV as major complications, and grade V as mortality (9).

Our study sought to elucidate the complications and mortality, and to assess the impact of these complications on survival in patients who underwent lung cancer surgery. Our objective was to assess complications following lung cancer surgery according to the Clavien-Dindo classification and demonstrate the use of this classification in thoracic surgery.

PATIENTS AND METHODS

Study Design: The study included patients who underwent lung resection for primary lung cancer at two clinics between January 2002 and December 2019. The study included 802 patients, all of whom had complete control and follow-up data, with no data loss. The study recorded whether the patients developed postoperative complications. We retrospectively reviewed data from 180 patients in this series who developed complications. We recorded the age, gender, type of complication, surgical technique, type of resection applied, and survival times. The Clavien-Dindo classification graded the complications as Grade 1, Grade 2, Grade 3A, Grade 3B, Grade 4A, Grade 4B, and Grade 5. Because 180 patients developed a total of 224 complications, we recorded data on the highest-grade complication for patients who experienced more than one.

Table 1. Clavien-Dindo classification of surgical complications.

Grade I	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions Allowed therapeutic regimens are: drugs as antiemetics, antipyretics, analgesics, diuretics, electrolytes, and physiotherapy. This grade also includes wound infections opened at the bedside
Grade II	Requiring pharmacological treatment with drugs other than such allowed for grade I complications Blood transfusions and total parenteral nutrition are also included
Grade III -Grade IIIa -Grade IIIb	Requiring surgical, endoscopic or radiological intervention -Intervention not under general anesthesia -Intervention under general anesthesia
Grade IV -Grade IVa -Grade IVb	Life-threatening complication (including central nervous system complications) requiring intermediate care/intensive care unit management -Single organ dysfunction (including dialysis) -Multiorgan dysfunction
Grade V	Death of a patient

Table 2. Grading of complication following TM & M classification system.

Grading		Definition/Treatment Performed
Minor Complications	Grade I	Adverse event which alters the standard postoperative course without requiring a specific treatment
	Grade II	Pharmacologic treatment or minor intervention required
Major Complications	Grade IIIa	Surgical, radiologic, endoscopic treatment, or multitherapy required without general anesthesia
	Grade IIIb	Surgical, radiologic, endoscopic treatment, or multitherapy required with general anesthesia
	Grade IVa	Intensive care unit treatment for single organ dysfunction required
	Grade IVb	Intensive care unit treatment for multiple organ dysfunction required
Mortality	Grade V	Adverse event which leads to death

Preoperative Evaluation: All patients underwent conventional oncological and surgical assessments. Radiological examinations included chest X-ray, computed tomography, and positron emission tomography (PET/CT). Comprehensive blood analyses and biochemical assessments were conducted. Respiratory function assessments were conducted. Advanced respiratory and cardiac evaluations were conducted when deemed essential during the patient's clinical assessment. Patients exhibiting peripheral tumor localization with a tumor diameter less than 3 cm and no mediastinal lymph node involvement as assessed by PET/CT did not receive preoperative mediastinal staging. Nonetheless, preoperative mediastinal staging was conducted using mediastinoscopy in all patients not meeting these criteria. Preoperative mediastinal staging guided management of patients with N2 disease toward systemic therapy, including neoadjuvant chemotherapy and/or definitive chemoradiation.

Postoperative follow-up: Patients underwent outpatient clinic evaluations at three-month intervals post-surgery. All outpatient clinic examinations included chest X-rays and biochemical analyses. Surveillance and management were conducted using thoracic tomography every six months during the first two years and annually thereafter. All patients were directed to the oncology outpatient clinic following surgery. Systemic adjuvant therapy, including chemotherapy and/or radiotherapy, was administered based on appropriate indications such as N1 or N2

disease and the presence of T2 tumors. Patients undergoing adjuvant oncological treatment were evaluated for treatment responses using PET/CT at designated intervals. All patient data were documented during these follow-ups.

Exclusion Criteria: The study excluded patients with benign pathology results, patients with missing data, and patients with incomplete survival information during follow-up.

Statistical Evaluation: Data analysis was performed using SPSS version 20.0 (SPSS Inc., Chicago, USA). Quantitative parametric data were expressed as mean $\pm$ standard deviation (SD), and quantitative non-parametric data were expressed as median (minimum–maximum). Kaplan-Meier and Cox regression analyses were performed. A p-value <0.05 was considered significant.

Ethics: Bolu Abant Izzet Baysal University Clinical Research Ethics Committee approval was obtained (22.06.2021/172).

RESULTS

Of 802 patients who underwent surgery with a diagnosis of lung cancer, 180 developed 224 complications. Complications developed in 19 female (10.6%) and 161 male (89.4%) patients. The mean age was 62.2 ± 9.4 (29–83 years) (Table 3).

Table 3. Demographic data.

	Patients (n=180, 22.4%)
Age	Mean:62.2± 9.4 (29–83)
Gender	
Female	19 (10.6%)
Male	161 (89.4%)

Table 4. Frequencies of complications.

Type of Complications	N	%
Prolonged Air Leak	54	6.73
Pneumonia	22	2.74
Arrhythmia	19	2.36
Hemorrhage	17	2.11
Respiratory Failure	15	1.87
Atelectasis	10	1.24
Pneumothorax/Re-expansion Failure	7	0.87
Cardiac Arrest	7	0.87
Bronchopleural Fistula	7	0.87
Subileus/ileus	6	0.74
Other	60	7.48
Total	224	27.88

Out of 180 patients, 22.4% experienced 224 complications. The most common complication was a prolonged air leak, occurring in 54 patients (6.73%). Other common complications included pneumonia (22 patients, 2.74%), arrhythmia (19 patients, 2.36%), respiratory failure (15 patients, 1.87%), hemorrhage (17 patients, 2.11%), atelectasis (10 patients, 1.24%), pneumothorax/expansion defect (7 patients, 0.87%), cardiac arrest (7 patients, 0.87%), bronchopleural fistula (7 patients, 0.87%), and subileus/ileus (6 patients, 0.74%). Table 4 provides the types and rates of complications.

Patients with complications most frequently underwent right upper lobectomies (55 patients, 30.6%). The second most common resection type was a left upper lobectomy (30 patients, 16.7%). The least common resection type in patients with complications was right middle lobectomy (3 patients, 1.7%) (Table 5).

Table 5. Distribution of surgery types.

Resection Types	N	%
Lobectomy		
RUL	55	30.6
RML	3	1.7
RLL	19	10.6
LUL	30	16.7
LLL	24	13.3
Pneumonectomy		
RP	9	5.0
LP	17	9.4
Bilobectomy		
RUBL	5	2.8
RLBL	8	4.4
SR	10	5.6
Total	180	100

RUL: Right upper lobectomy, RML: Right middle lobectomy, RLL: Right lower lobectomy, LUL: Left upper lobectomy, LLL: Left lower lobectomy, RP: Right pneumonectomy, LP: Left pneumonectomy, RUBL: Right upper bilobectomy, RLBL: Right lower bilobectomy, SR: Sublobar resection (wedge and segmentectomy).

Table 6. Complication rates according to the Clavien-Dindo classification.

Grade		N	%
Minor Complications	Grade I	46	25.6
	Grade II	64	35.6
Major Complications	Grade IIIa	22	12.2
	Grade IIIb	12	6.7
	Grade IVa	10	5.6
	Grade IVb	10	5.6
Mortality	Grade V	16	8.9

The distribution of complications according to the Clavien-Dindo classification was as follows: Grade I: 46 patients (25.6%); Grade II: 64 patients (35.6%); Grade IIIa: 22 patients (12.2%); Grade IIIb: 12 patients (6.7%); Grade IVa: 10 patients (5.6%); Grade IVb: 10 patients (5.6%); Grade V: 16 patients (8.9%) (Table 6).

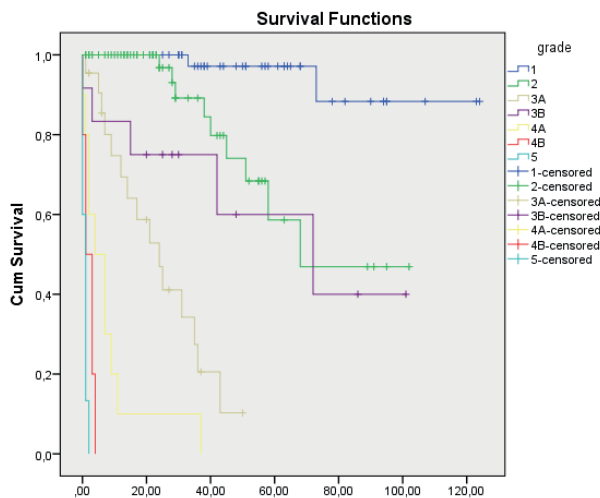


Figure 1. Survival analysis according to Clavien-Dindo classification. As the complication stage increases, survival is observed to be statistically significantly worse ($p < 0.001$).

In the survival analysis, it was seen that survival decreased statistically significantly as the Clavien-Dindo complication grade increased ($p < 0.001$) (Figure 1).

The 5-year survival of all patients was 62.3% (179 ± 28.7) (Figure 2). In the regression analysis performed on all patients, cancer stage, development of complications, age, and tumor size were significantly associated with survival.

DISCUSSION

Our study demonstrated a correlation between the Clavien-Dindo classification of complications and long-term survival in patients undergoing lung resection for lung cancer. We demonstrated the usability and suitability of the Clavien-Dindo classification following thoracic surgical procedures.

Although the morbidity and mortality of lung cancer surgery have decreased in recent years, they are still high (6,10,11). There are various risk factors for complications after lung cancer surgery (12). There

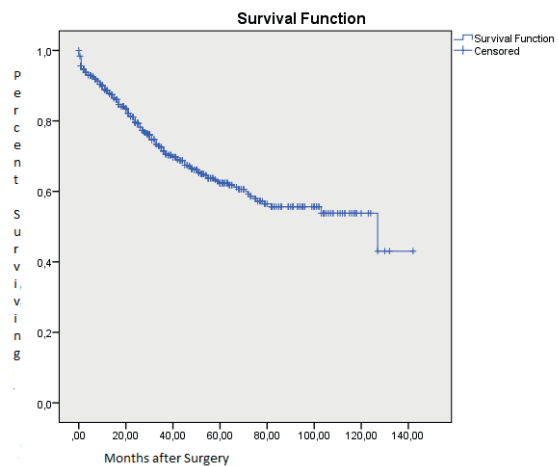


Figure 2. Survival analysis.

are differences in both the definition and classification of postoperative complications (6,9,13,14). There is a need for a common complication definition and classification used worldwide (6,9,13,14).

Dindo et al. emphasized that there is no consensus yet on how to define postoperative complications and that this prevents standardization (7,8). Therefore, they conducted an international survey of general surgeons and evaluated 6336 patients. They modified their classification recommendations, which they had issued since 1992, and attempted to standardize them in this study. In their 2009 study, the same researchers conducted a 5-year evaluation, revealing the validity and use of this classification across various surgical branches and many countries worldwide (7,8).

The most common complication after thoracic surgery is arrhythmia, followed by prolonged air leakage (15). Postoperative pain and prolonged air leakage are the most common causes of delayed discharge (15). Prolonged air leakage is also among the most important causes of postoperative morbidity (15,16). The literature reports that air leakage lasting more than five days causes 9.6% of morbidity after lobectomy, and 5.9% after segmentectomy (15,16). Varela et al. showed that prolonged air leakage is associated with important pulmonary complications such as atelectasis, pneumonia, and empyema (17).

Numerous studies have evaluated the complications that arise from thoracic surgery operations, using the Clavien-Dindo classification (18,19). The Clavien-Dindo classification was used by Esteva et al. to look at the problems that came up after 31 Nuss surgeries for pectus excavatum (18). They found that the Clavien-Dindo classification can be used and can be repeated after pectus excavatum surgery (18).

Watanabe et al. used the Clavien-Dindo classification in their study evaluating 43 patients receiving hemodialysis who required lung resection (19). They showed that increased smoking and prolonged surgery time caused the development of Grade 2 and higher complications (19).

The Clavien-Dindo classification has been modified and used to classify complications in thoracic surgery (6,9). The European Society of Thoracic Surgeons (ESTS) arranged the Clavien-Dindo classification using the thoracic surgery database, with Grade I-II being minor complications, Grade III-IV being major complications, and Grade V being mortality (6,9). When we revised our Clavien-Dindo classification according to the TM & M classification, 110 (61.2%) of the patients were classified as having minor complications, 54 (30.1%) as having major complications, and 16 (8.9%) died.

Due to data loss, we evaluated the limitations of our retrospective study, which excluded some patients.

In our study, we modified the Clavien-Dindo classification for complications after lung cancer surgery and showed that Clavien-Dindo grading is an applicable method for analyzing these complications.

Ethical approval

This study has been approved by the Bolu Abant İzzet Baysal University Clinical Research Ethics Committee (approval date 22/06/2021, number 172).

Author contribution

Concept: OY, HAK; Design: EE, MYH, AT, KK; Data Collection or Processing: MYH, EE, HAK; Analysis or Interpretation: KK, OY, EE, HAK; Literature Search: OY, MYH, EE; Writing: OY, HAK, MYH, EE. All authors

reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

REFERENCES

1. Schabath MB, Cote ML. Cancer progress and priorities: lung cancer. *Cancer Epidemiol Biomarkers Prev.* 2019; 28(10): 1563-79. [\[Crossref\]](#)
2. Thandra KC, Barsouk A, Saginala K, Aluru JS, Barsouk A. Epidemiology of lung cancer. *Contemp Oncol (Pozn).* 2021; 25(1): 45-52. [\[Crossref\]](#)
3. Goldstraw P, Chansky K, Crowley J, et al. The IASLC Lung Cancer Staging Project: proposals for revision of the TNM stage groupings in the forthcoming (Eighth) edition of the TNM classification for lung cancer. *J Thorac Oncol.* 2016; 11(1): 39-51. [\[Crossref\]](#)
4. Chaft JE, Rimner A, Weder W, Azzoli CG, Kris MG, Cascone T. Evolution of systemic therapy for stages I-III non-metastatic non-small-cell lung cancer. *Nat Rev Clin Oncol.* 2021; 18(9): 547-57. [\[Crossref\]](#)
5. Grunewald DH. Surgery for advanced stage lung cancer. *Semin Surg Oncol.* 2000; 18(2): 137-42. [\[Crossref\]](#)
6. Allen MS, Darling GE, Pechet TT, et al. Morbidity and mortality of major pulmonary resections in patients with early-stage lung cancer: initial results of the randomized, prospective ACOSOG Z0030 trial. *Ann Thorac Surg.* 2006; 81(3): 1013-9; discussion 1019-20. [\[Crossref\]](#)
7. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. *Ann Surg.* 2009; 250(2): 187-96. [\[Crossref\]](#)
8. Bolliger M, Kroehnert JA, Molineus F, Kandioler D, Schindl M, Riss P. Experiences with the standardized classification of surgical complications (Clavien-Dindo) in general surgery patients. *Eur Surg.* 2018; 50(6): 256-61. [\[Crossref\]](#)
9. Salati M, Refai M, Pompili C, Xiumè F, Sabbatini A, Brunelli A. Major morbidity after lung resection: a comparison between the European Society of Thoracic Surgeons Database system and the Thoracic Morbidity and Mortality system. *J Thorac Dis.* 2013; 5(3): 217-22. [\[Crossref\]](#)
10. Jacobson FL, Dezube AR, Bravo-Iñiguez C, et al. Preserving NLST mortality benefits and acceptable morbidity for lung cancer surgery in a community hospital. *J Surg Oncol.* 2021; 124(1): 124-34. [\[Crossref\]](#)

11. Ginsberg RJ. Lung cancer surgery: acceptable morbidity and mortality, expected results and quality control. *Surg Oncol.* 2002; 11(4): 263-6. [\[Crossref\]](#)
12. Motono N, Ishikawa M, Iwai S, Iijima Y, Usuda K, Uramoto H. Individualization of risk factors for postoperative complication after lung cancer surgery: a retrospective study. *BMC Surg.* 2021; 21(1): 311. [\[Crossref\]](#)
13. Rotman JA, Plodkowski AJ, Hayes SA, et al. Postoperative complications after thoracic surgery for lung cancer. *Clin Imaging.* 2015; 39(5): 735-49. [\[Crossref\]](#)
14. He T, Guo J, Chen N, et al. MediMLP: using Grad-CAM to extract crucial variables for lung cancer postoperative complication prediction. *IEEE J Biomed Health Inform.* 2020; 24(6): 1762-71. [\[Crossref\]](#)
15. Shaw JP, Locicero III J . Postoperative management of the general thoracic surgical patient. In: Shields TW, Locicero III J, Reed CE, Feins RH, editors. *General Thoracic Surgery.* 7th ed. Philadelphia: Lippincott Williams and Wilkins; 2009: 571-579.
16. Haithcock BE, Feins RH. Complications of pulmonary resection. In: Shields TW, Locicero III J, Reed CE, Feins RH, editors. *General Thoracic Surgery.* 7th ed. Philadelphia: Lippincott Williams and Wilkins; 2009: 551-559.
17. Varela G, Jiménez MF, Novoa N, Aranda JL. Estimating hospital costs attributable to prolonged air leak in pulmonary lobectomy. *Eur J Cardiothorac Surg.* 2005; 27(2): 329-33. [\[Crossref\]](#)
18. Esteva Miró C, Núñez García B, Pérez-Gaspar M, et al. Applicability of Clavien-Dindo classification in Nuss procedure surgical complications. *Cir Pediatr.* 2020; 33(4): 154-9.
19. Watanabe Y, Hattori A, Fukui M, et al. Postoperative complications and perioperative management in patients on hemodialysis undergoing lung resection. *Gen Thorac Cardiovasc Surg.* 2021; 69(3): 478-86. [\[Crossref\]](#)