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Risk factors for postoperative complications and long-term survival in elderly lung cancer patients: a single institutional experience in Turkey

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Abstract

Background Lung cancer is a typical disease of elderly patients. While there are many publications in the literature on factors affecting survival, there is still no consensus on the survival impact of lymph node dissection. Our objective in this study was to evaluate prognostic factors influencing rates of complications, mortality, and survival in geriatric patients who underwent surgery for non-small cell lung cancer.

Materials and methods Data obtained from the medical records of patients aged 70 years or older with early-stage non-small cell lung cancer who underwent surgery between January 01, 2008 and December 31, 2015 were evaluated retrospectively.

Results Of the 72 patients included, 57 (79.2%) were male and 15 (20.8%) were female. Complications were observed in 42 patients (58.3%). Nineteen patients (26.4%) developed major complications. Percent predicted forced expiratory volume in 1 s (ppFEV1) and age was found to be risk factors for complications. Thirty days days mortality rate was 8.3%. Mortality was not significantly associated with low CCI, physical status, and ppFEV1 values. The 5-year survival rate was 40.5%. ppFEV1 were risk factors affecting survival, whereas radical lymph node dissection was not associated with survival.

Conclusion The main prognostic factors affecting long-term postoperative survival in the present study was a low postoperative ppFEV$_1$ value. Radical lymph node dissection did not increase the risk of postoperative complications and it did not affect long-term survival in patients aged 70 years or older. A key finding was that comorbidities were not associated with postoperative complications or long-term survival.

Keywords Geriatric patients · Non-small cell lung cancer · Complication · Lung resection

Introduction

Lung cancer continues to be a global health issue, causing more deaths than prostate, colon, and breast cancers combined [1]. For this reason, it remains the leading cause of cancer deaths worldwide. Lung cancer is a typical disease of elderly patients, with peak incidence after 60–70 years of age. With a growing population, the treatment approach to lung cancer in the elderly has become one of the most important current issues. Improvements in technology and postoperative intensive care facilities have resulted in a growing number of patients being referred for surgical treatment. However, curative lung cancer surgery is performed 22% less frequently among patients aged 75 years or older compared to their younger counterparts [2].

Surgical treatment is the best option for early non-small cell lung cancer (NSCLC). According to a 2005 Surveillance, Epidemiology and End Results (SEER) study, early NSCLC was detected in 87% of patients over 75 years old [3]. Similarly, a study by O'Rourke et al. [4] using data from the Centralized Cancer Patient Data System, 15.3% of patients 54 years and younger had a local disease, while this rate increased to 25.4% among patients aged 75 years or older. However, although there are many publications in the literature regarding factors affecting survival, there is still no consensus on the survival impact of lymph node dissection.

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Our objective in this study was to evaluate prognostic factors influencing rates of complications, mortality, and survival in geriatric patients who underwent surgery for NSCLC.

Materials and methods

Early-stage NSCLC patients aged 70 years or older who underwent surgery in our hospital between January 1, 2008 and December 31, 2015 were included in the study. Routinely collected data in the hospital database were evaluated retrospectively. The study was approved by the institutional review board and was conducted in accordance with the principles of the Declaration of Helsinki.

Patient selection

Tumor location and invasion were assessed in all patients preoperatively with routine thoracic computed tomography (CT). Positron emission tomography was used to assess distant and mediastinal metastases. Contrast-enhanced cranial magnetic resonance imaging was performed to assess cranial metastases. All patients underwent preoperative bronchoscopy. Mediastinal evaluations were performed with endobronchial ultrasound (EBUS) and/or mediastinoscopy. Pulmonary function tests (PFT), arterial blood gas tests, and electrocardiography (ECG) were routinely requested to evaluate cardiopulmonary capacity. Patients with cardiac comorbidities were assessed with ECG by the cardiology department. Patients with percent predicted forced expiratory volume in 1 s (ppFEV$_1$) of 40% or below in preoperative pulmonary function tests were subjected to further pulmonary assessment with diffusing capacity of the lung for carbon monoxide (DLCO) testing, pulmonary perfusion scintigraphy, and 6-min walk test.

Performance status was assessed using the Eastern Cooperative Oncology Group (ECOG) performance status scale, in which a score of 0–1 indicates good performance status while scores of 2–5 correspond to poor performance status. The comorbidity score was calculated according to the 19-parameter Charlson Comorbidity Index (CCI), introduced in 1987 [5].

After anatomic resection, patients were divided into two groups: those who underwent regional lymph node dissection and/or sampling (LN1) and those who underwent systematic mediastinal lymph node dissection after resection (LN2).

Postoperative complications were defined as complications occurring while in a hospital or within the first 30 days after surgery. Complications were classified as major or minor. Major complications included acute renal failure, pneumonia (newly developed shadow on chest X-ray and purulent sputum both treated with antibiotics), bronchopleural fistula (BPF), and empyema; minor complications

included prolonged air leak (PAL; lasting 7 days or longer), arrhythmia (atrial arrhythmia, fibrillation, flutter tachycardia, and bradyarrhythmia), hoarseness, chylothorax, and lobar atelectasis.

Mortality was evaluated as deaths that occurred within the first 30 days after surgery. Patients were followed postoperatively for an average of 45 months.

The patients were analyzed in terms of demographic data, morbidity, length of hospital stay, mortality, and histopathological characteristics. All cases were restaged according to the 8th edition of the TNM classification system [6].

Table 1 Patients demographic characteristics

Variables	n	(%)
Gender (male/female)	57/15	79.2/20.8
Age	73.82 ± 3.39	
70–75	45	62.5
> 75	27	37.5
Smoking history		
No/yes	12/68	15/85
Packet/year	38.7 ± 17.03	
CCI		
0	28	38.9
1	13	18.1
2	6	8.3
3	10	13.9
4	8	11.1
5	3	4.2
6	2	2.8
7	1	1.4
8	1	1.4
ppFEV1 < 40	76.6 ± 15.9	
ECOG		
0	11	15.3
1	38	52.8
2	13	18.1
3	10	13.9
Side (right/left)	37/35	51.4/48.6
Resection type		
Segmentectomy	8	11.1
Lobectomy	56	77.8
Pneumonectomy	8	11.1
Lymph node		
LN-1	18	25
LN-2	54	75
Histopathology		
Adenocarcinoma/squamous cell carcinoma/others	35/28/9	48.6/38.9/12.5
Tumor stage		
1	29	40.3
2	43	59.7

Statistical analysis

SPSS Version 22.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analyses. The chi-squared (χ^2) test was used to calculate frequency values as descriptive statistics. A t test was used to compare the means of independent groups and the Mann–Whitney U was used to compare medians. Survival analysis was conducted according to the Kaplan–Meier method and curves were compared using the log-rank test. The statistical significance level was accepted as $p < 0.05$ for all analyses.

Results

Fifty-seven (79.2%) of the 72 patients in the study were male and 15 (20.8%) were female. The mean age was 73.82 ± 3.39 years (range 70–84 years) and the patients' mean smoking history was 38.7 ± 17.03 pack-years. The mean length of hospital stay was 8.67 ± 7.50 days (range 4–49 days). Forty-four (61.1%) of the patients had comorbidities. The most common were pulmonary comorbidities, present in 38.9% of the patients. The patients' demographic characteristics are shown in Table 1.

Complications were observed in 42 patients in the study (58.3%). Nineteen patients (26.4%) developed major complications and 44 (61.1%) developed minor complications. Arrhythmia was the most common complication, occurring in 41 patients (56.9%). Of the 15 patients (20.8%) who developed atelectasis, 6 underwent secretion clearance with fiberoptic bronchoscopy. Seven patients (9.7%) experienced hemorrhage, which was controlled surgically in 3 cases. Chylothorax was detected in 2 patients (2.8%), both of whom improved with somatostatin treatment. Five patients (6.9%) developed ARDS and all of them died. Pneumonia developed in 9 patients (12.5%), 1 of whom had undergone segmentectomy while the other 8 had lobectomy ($p = 0.520$). Two patients (2.8%) had permanent hoarseness and 13 patients (18.1%) had PAL. Blood pleurodesis was performed in 8 patients. Of these, 3 patients showed spontaneous regression of the leak, 2 patients died, and 3 patients (4.2%) developed BPF. Two of the patients with BPF were reoperated (completion pneumonectomy) and died postoperatively. A stoma was created in 1 patient due to micro fistulas. In the univariate analysis age, ppFEV$_1$ value and radical lymph node dissection were found to be risk factors for complications. And risk factors for major complications were poor performance status and low ppFEV$_1$. However, in multivariate analysis, only ppFEV1 was effective in the major complications (Table 2).

Although there was no intraoperative mortality, 6 patients (8.3%) died within the first 30 days postoperatively.

Table 2 Evaluation of factors affecting complications

Variables	Complication* n (%)	Major complication** n (%)	Univariate analysis		Multivariate analysis	
			p value*	p value**	p value*	p value**
Age (year)	74.83 ± 3.62	74.58 ± 3.50	0.003	0.205	0.02	ns
Gender						
Male/female	35 (83.3)/7 (16.7)	16 (84.2)/3(15.8)	0.303	0.528	ns	
ppFEV$_1$ < 40%	10 (23.8)	7 (36.8)	0.004	0.001		0.022
ECOG						
Good performance	26 (63.9)	9 (47.4)	0.185	0.024		ns
Poor performance	16 (38.1)	10 (52.6)				
CCI						
0–1	23 (54.8)	8 (42.1)	0.658	0.128		
>2	19 (45.2)	11 (57.9)				
Lymph node						
LN-1	7 (16.7)	2 (10.5)	0.050	0.089		
LN-2	35 (83.3)	17 (89.5)				
Side (right/Left)	19 (45.2)/23.8 (54.8)	11 (57.9)/8 (42.1)	0.217	0.508		
Resection Type						
Segmentectomy	5 (11.9)	1 (5.3)	0.556	0.360		
Lobectomy	31 (73.8)	17 (89.5)				
Pneumonectomy	6 (14.3)	1 (5.3)				
8th stage						
1	16 (38.1)	7 (36.8)	0.655	0.722		
2	26 (61.9)	12 (63.2)				

*Complications p value

**Major complications p value

Mortality was not associated with sex, smoking, number of lymph nodes removed, or the side and type of operation. Significant associations were observed between mortality and low CCI, performance status, and $ppFEV_1$ values in univariate analysis. However, in multivariate analysis, no factor affecting mortality was found (Table 3).

The 5-year survival rate was 40.5% and median survival was 51 months. Pathologically, 49% of the patients had stage I and 34% had stage II disease ($p = 0.959$). Among patients with low ppFEV1, 2-year survival was 60% and there was no 5-year survival ($p = 0.003$) (Fig. 1; Table 4).

There was no statistical association between operation type and survival time in the LN1 or LN2 group ($p = 0.129$, $p = 0.076$). There was also no significant relationship between disease stage and survival in the LN1 or LN2 group (5-year survival in LN1: 55.6% for stage I, 61% for stage II patients [$p = 0.710$]; 5-year survival in LN2: 46.2% for stage I, 27.9% for stage II [$p = 0.235$]). Survival was not statistically associated with ECOG performance status in the LN1 group ($p = 0.656$). In the LN2 group, however, the 5-year survival rate of patients with the good performance was 43.7%, compared to 20.7% among those with poor performance ($p = 0.014$).

Discussion

Middle East Cancer Consortium study in lung cancer incidence in Turkey is observed at 0.32%. The rate of newly diagnosed cancer patients under 70 is 68.6%. 25.5% in the 70–79 age group and 5.6% in the 80 age group. The incidence of squamous cell cancer is 28.2% and the adenocarcinoma is 23.1% [7].

The prevalence of radical surgical treatment is increasing among elderly patients. The important question is how aggressive these surgeries should be. Acceptable oncologic results after surgery have been reported for geriatric patients [8–13]. The size of the resection does not affect oncologic outcomes. However, larger resections are associated with a higher risk of postoperative complications and mortality [14]. For this reason, limited resections are recommended to reduce the risk of postoperative complications [15]. In addition, it is stated that in limited resections, survival outcomes of segmentectomy and lobectomy are similar, while radical lymph node dissection and the size of surgical resection affect survival [3, 15, 16].

The most common postoperative complications observed in the patients aged 70 years or older in this study were arrhythmia, PAL, and pneumonia. Saji et al. [17] reported

Table 3 Evaluation of factors affecting mortality

Variables	Mortality		Univariate analysis	Multivariate analysis
	No n (%)	Yes n (%)	p value	p value
Age (Year)	73.58 ± 3.19	76.50 ± 4.59	0.111	n.s
Gender				
Male/female	51 (77.3)/15 (22.7)	6 (100)/0	0.333	
$ppFEV_1 < 40$	6 (9.1)	4 (66.7)	0.001	
ECOG				
Good performance	49 (74.2)	0	< 0.001	
Poor performance	17 (25.8)	6 (1009		
CCI				
0–1	41 (62.1)	0	0.003	
> 2	25 (37.9)	6 (100)		
Resection type				
Segmentectomy	51 (77.3)	5 (83.3)	0.627	
Lobectomy	8 (12.1)	0		
Pneumonectomy	7 (10.6)	1 (16.7)		
Lymph node				
LN-1	17 (25.8)	1 (16.7)	0.622	
LN-2	49 (74.2)	5 (83.3)		
Histopathology				
Adenocarcinoma	34 (59.6)	1 (16.7)	0.080	
Squamous cell carcinoma	23 (40.4)	5 (83.3)		
8th stage				
1	27 (40.9)	2 (33.3)	0.717	
2	39 (59.1)	4 (66.7)		

Table 4 Evaluation of factors affecting survival

Variables	5-year survival	Median survival	Univariate analysis		Multivariate analysis	
			95% CI	p value	HR	p value
Age (years)						
70–74	46.1	54	46.3–61.6	0.682	ns	ns
> 75	34.2	41	23.6–58.3			
CCI						
0–1	44.3	54	44.9–63	0.186		
> 2	35.7	45	33.9–56			
$ppFEV_1 < 40$	0	25	0–70.4	0.003	4.82	0.008
ECOG						
Good performance	46.7	57	41–72.9	0.029	1.46	0.488
Poor performance	26.6	45	33.6–56.3			
Resection type						
Segmentectomy	33.3	49	33.5–64.4	0.117	ns	ns
Lobectomy	44.6	54	47.1–60.8			
Pneumonectomy	23.4	30	20.6–39.3			
Lymph node						
LN-1	35.5	51	37.3–64.6	0.607		
LN-2	42.4	54	46.1–61.8			
8th stage						
1	49	53	42.7–63.2	0.329		
2	34	51	41.6–60.3			
Histopathology						
Adenocarcinoma	38.8	49	38.3–59.7	0.825		
Squamous cell carcinoma	46.7	53	39-66.9			

HR Hazard ratio, *CI* confidence interval, *UA* univariate analysis, *MA* multivariate analysis

a complication rate of 34% in octogenarian patients. They were most frequently followed by pneumonia in 3%. These results are similar to previous studies [18–21]. Complications were not found to be associated with comorbidities, age, sex, or type of resection in our study. In the univariate analysis Low $ppFEV_1$ value, age, radical lymph node dissection, and performance status were identified as risk factors for complications. However, in multivariate analysis only age risk factor was determined. Risk factors associated with complications vary in the literature. For example, Chida et al. [22] observed no correlation between complications and CCI score of 2 or above, whereas Birim et al. [23] reported that CCI score of 3 or above is a risk factor for major complications. In our study, we did not show the effect of radical lymph node dissection on complication due to the low number of patients aged 80 and over. However, in the literature, the risk of lymph node dissection should be required, and the risk of complication increases in octogenarians [24, 25].

The 30-day mortality rate among early-stage lung cancer patients in our study was 8.3%. Type of resection, age, and radical lymph node dissection was not statistically associated with mortality. In the univariate analysis, the main risk factors affecting mortality were the patients' performance status, CCI score of 2 or higher, and low $ppFEV_1$ value. However, multivariate analysis revealed no risk factor affecting mortality. The lack of a mortality difference according to resection type may be due to the better performance status of pneumonectomy patients. Similarly, Okami et al. [25] also reported that the type of lung resection was not an independent risk factor and did not have an impact on mortality. In particular, the patient's performance status and disease stage constitute postoperative prognostic factors. Unlike other authors, Mizushima [26] reported that resection type affected mortality in patients aged 70 years or older. They determined a 22% mortality rate among patients who underwent pneumonectomy.

In our study, radical lymph node dissection and resection type were not associated with survival. Radical lymph node dissection was only a significant risk factor in terms of survival in patients with poor performance status in the univariate analysis. Chida et al [16] reported that radical lymph node dissection was associated with significantly greater survival. However, recent studies have shown that full lymph node dissection after pulmonary resection had no impact on long-term survival [20, 27]. Chida et al.
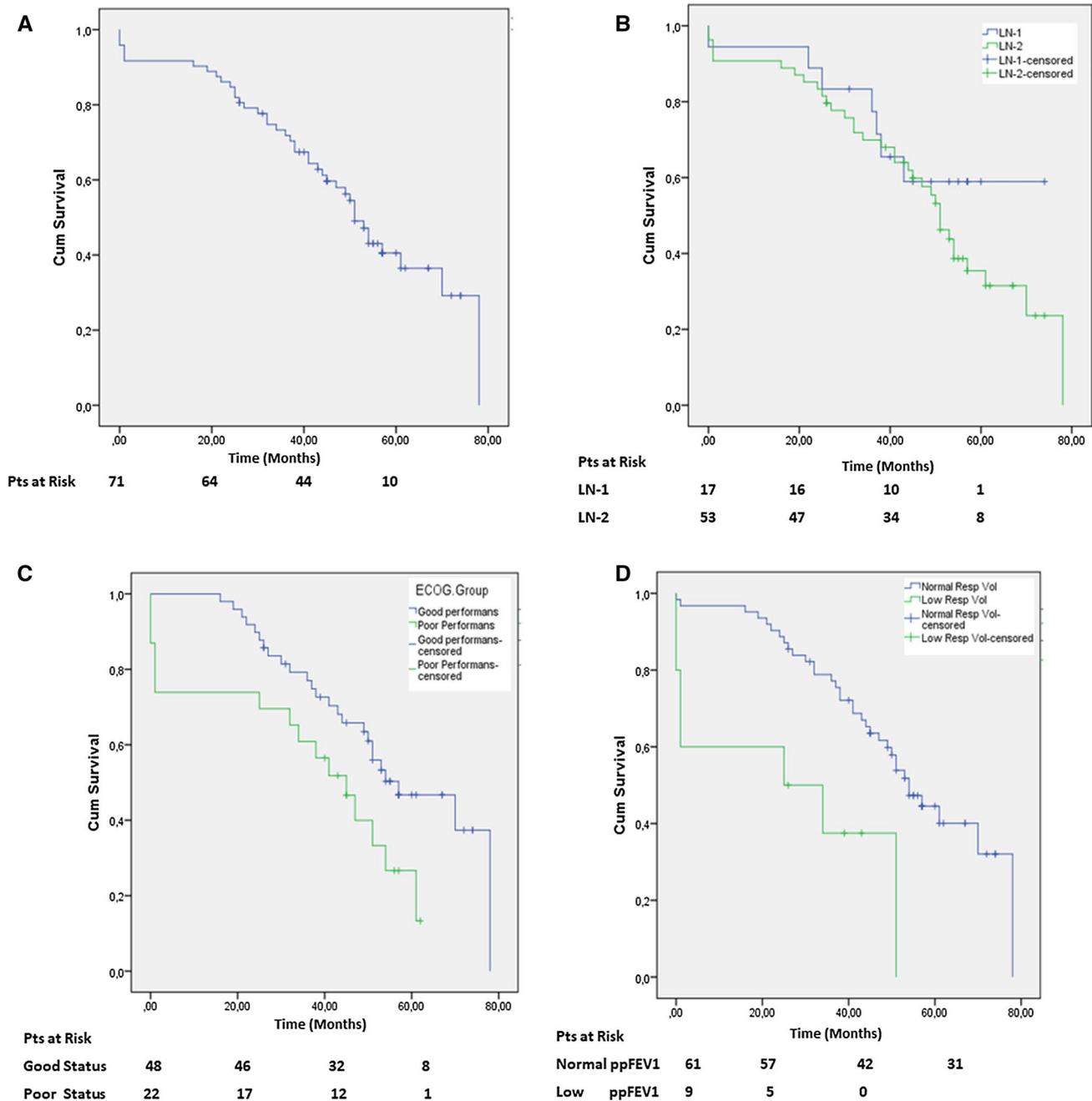
Fig. 1 Kaplan–Meier curve analysis of **a** overall survival, **b** LN1 and LN2 groups, **c** performance status, **d** percent predicted FEV1

[22] found that long-term survival outcomes were worse in early-stage lung cancer patients who underwent radical lymph node dissection compared to those who underwent lymph node sampling. We believe that sampling is sufficient in elderly patients because lymph node dissection poses a complication risk, has not been shown to improve survival, and actually reduces survival in patients in poor general condition.

Limitations

Limitations of this study include selection bias, its retrospective design, small sample size, single institutional study, and the lack of comparative analysis between patients older than 70 years and those younger than 70 years. In addition, performance status heterogeneity in patients undergoing different types of resection, and the lack of performance analyses other than ECOG are other limitations.

Conclusion

The main prognostic factors affecting long-term postoperative survival in the present study was a low postoperative ppFEV$_1$ value. Radical lymph node dissection did not increase the risk of postoperative complications and it did not affect long-term survival in patients aged 70 years or older. A key finding was that comorbidities were not associated with postoperative complications or long-term survival.

Compliance with ethical standards

Conflict of interest The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Siegel A, Ward R. E et al. Cancer statistics. CA Cancer J Clin. 2007;57:43–66.
2. Jemal A, Bray F, Center MM, Ferlay J, Ward E, Forman D. Global cancer statistics. CA Cancer J Clin Wiley Online Library. 2011;61:69–90.
3. Mery CM, Pappas AN, Bueno R, Colson YL, Linden P, Sugarbaker DJJM. Similar long-term survival of elderly patients with non-small cell lung cancer treated with lobectomy or wedge resection within the surveillance, epidemiology, and end results database. Chest Elsevier. 2005;128:237–45.
4. O'Rourke MA, Feussner JR, Feigl P, Laszlo J. Age trends of lung cancer stage at diagnosis: implications for lung cancer screening in the elderly. JAMA Am Med Assoc. 1987;258:921–6.
5. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic in longitudinal studies: development. J Chron Dis. 1987;40:373–83.
6. Goldstraw P, Chansky K, Crowley J, Rami-Porta R, Asamura H, Eberhardt WEE, 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;11:39–51.
7. Eser S, Chang J, Charalambous H, Silverman B, Demetriou A, Yakut C, et al. Incidence patterns of colorectal cancers in four countries of the Middle East Cancer Consortium (Cyprus, Jordan, Israel, and Izmir, Turkey) compared with those in the United States Surveillance, Epidemiology, and End Results Program. Turkish J Gastroenterol. 2018;29:35–43.
8. Stamenovic D, Messerschmidt A, Schneider T. Surgery for lung tumors in the elderly: a retrospective cohort study on the influence of advanced age (over 80 years) on the development of complications by using a multivariate risk model. Int J Surg Elsevier. 2018;52:141–8. https://doi.org/10.1016/j.ijsu.2018.02.008.
9. Onaitis MW, Furnary AP, Kosinski AS, Kim S, Boffa D, Tong BC, et al. Prediction of long-term survival after lung cancer surgery for elderly patients in the society of thoracic surgeons general thoracic surgery database. Ann Thorac Surg [Internet]. The Society of Thoracic Surgeons. 2018;105:309–16. https://doi.org/10.1016/j.athoracsur.2017.06.071.
10. Kent M. Lung cancer surgery in the elderly: age is just a number. Semin Thorac Cardiovasc Surg [Internet]. Elsevier Inc. 2017;29:548–9. https://doi.org/10.1053/j.semtcvs.2017.11.010.
11. Bravo-Iñiguez C, Perez Martinez M, Armstrong KW, Jaklitsch MT. Surgical resection of lung cancer in the elderly. Thorac Surg Clin [Internet]. Elsevier Inc. 2014;24:371–81. https://doi.org/10.1016/j.thorsurg.2014.07.001.
12. Gonzalez-Aragoneses F, Moreno-Mata N, Simon-Adiego C, Peñalver-Pascual R, Gonzalez-Casaurran G, Perea LA. Lung cancer surgery in the elderly. Crit Rev Oncol Hematol. 2009;71:266–71.
13. Aoki T, Tsuchida M, Watanabe T, Hashimoto T, Koike T, Hirono T, et al. Surgical strategy for clinical stage I non-small cell lung cancer in octogenarians. Eur J cardio-thoracic Surg. Oxford University Press. 2003;23:446–50.
14. Party BTSS of CS of GBIW. Guidelines on the selection of patients with lung cancer for surgery. Thorax. BMJ Publishing Group Ltd. 2001;56:89–108.
15. Kobayashi K, Shimizu J, Oda M, Murakami S, Hayashi Y, Ietsugu K, et al. Evaluation of surgical treatment in patients over 80 years of age with lung cancer. Kyobu Geka. 1993;46:103–6.
16. Chida M, Minowa M, Karube Y, Eba S, Okada Y, Miyoshi S, et al. Worsened long-term outcomes and postoperative complications in octogenarians with lung cancer following mediastinal lymph-node dissection. Interact Cardiovasc Thorac Surg. Oxford University Press. 2009;8:89–92.
17. Saji H, Ueno T, Nakamura H, Okumura N, Tsuchida M, Sonobe M, et al. A proposal for a comprehensive risk scoring system for predicting postoperative complications in octogenarian patients with medically operable lung cancer: JACS1303. Eur J Cardio-Thoracic Surg. Oxford University Press. 2017;53:835–41.
18. Brock MV, Kim MP, Hooker CM, Alberg AJ, Jordan MM, Roig CM, et al. Pulmonary resection in octogenarians with stage I nonsmall cell lung cancer: a 22-year experience. Ann Thorac Surg Elsevier. 2004;77:271–7.
19. Dominguez-Ventura A, Allen MS, Cassivi SD, Nichols FC III, Deschamps C, Pairolero PC. Lung cancer in octogenarians: factors affecting morbidity and mortality after pulmonary resection. Ann Thorac Surg Elsevier. 2006;82:1175–9.
20. Hino H, Karasaki T, Yoshida Y, Fukami T, Sano A, Tanaka M, et al. Risk factors for postoperative complications and long-term survival in lung cancer patients older than 80 years. 2018;53:980–6.
21. Saji H, Ueno T, Nakamura H. Prospective observational cohort study of postoperative risk and prognosis scoring for elderly patients with medically operable lung cancer (JACS1303). Gen Thorac Cardiovasc Surg. 2016;10:634–5.
22. Chida M, Minowa M, Karube Y, Eba S, Okada Y. Institutional report—pulmonary Worsened long-term outcomes and postoperative complications in octogenarians with lung cancer following mediastinal lymph-node dissection. Interact Cardiovasc Thoracic Surg 2018;8:89–92.
23. Birim Ö, Zuydendorp HM, Maat APWM, Kappetein AP, Eijkemans MJC, Bogers AJJC. Lung resection for non-small-cell lung cancer in patients older than 70: mortality, morbidity, and late survival compared with the general population. Ann Thorac Surg Elsevier. 2003;76:1796–801.
24. Hino H, Karasaki T, Yoshida Y, Fukami T, Sano A, Tanaka M, et al. Risk factors for postoperative complications and long-term survival in lung cancer patients older than 80 years. Eur J Cardio-Thoracic Surg. Oxford University Press. 2017;53:980–6.
25. Okami J, Higashiyama M, Asamura H, et al. Pulmonary resection in patients aged 80 years or over with clinical stage I non-small

cell lung cancer: prognostic factors for overall survival and risk factors for. New York: Elsevier; 2009. https://www.sciencedirect.com/science/article/pii/S1556086415312260. Accessed 29 Jun 2018

26. Mizushima MDY, Noto MDH, Sugiyama MDS, Kusajima MDY, Yamashita MDR, Kashii MDT, et al. Survival and prognosis after pneumonectomy for lung cancer in the elderly. Ann Thorac Surg Elsevier. 1997;64:193–8.

27. Rivera C, Falcoz PE, Rami-Porta R, Velly JF, Begueret H, Roques X, et al. Mediastinal lymphadenectomy in elderly patients with non-small-cell lung cancer. Eur J Cardiothorac Surg. 2012. https://academic.oup.com/ejcts/article-abstract/44/1/88/422474. Accessed 30 Jun 2018