

# Lung cancer in elderly patients

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**Abstract:** There is a worldwide-accepted evidence of a population shift toward older ages. This shift favors an increased risk of developing lung cancer that is primarily a disease of older populations. Decision making is extremely difficult in elderly patients, since this group is under-represented in clinical trials with only 25% of them historically opening to patients older than 65 years. For all these reasons, a “customized” preoperative assessment to identify physiological or pathological frailty should be encouraged since standard tools may be less reliable. The work already done to improve patient selection for lung surgery in the elderly population clearly shows that surgical resection seems the treatment of choice for early stage lung cancer. Further studies are required to improve outcome by reducing postoperative morbidity and mortality.

**Keywords:** Lung cancer; elderly patients; lung resection

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There is a worldwide-accepted evidence of a population shift toward older ages. The current life expectancy in the United States is 78.7 years compared to 49 years in 1900 (1). By the second half of this century more than 20% of the population will be older than 65 years (2,3). Increased life expectancy reflects, in part, a better understanding of the diseases, new interventions, and the success of public health programs.

The open question is what age cutoff should be used to define “elderly”. In Europe and in the USA an age greater than 70 is accepted to define this variable (4). However, some authors define elderly patients in geriatric oncology as “old” when their clinical status starts to interfere with oncologic decision making (5,6).

This shift favors an increased risk of developing disorders that are more common at a more advanced age. Lung cancer is one of them since it is primarily a disease of older populations; in fact, less than 0.5% of lung cancer related deaths occur at a age younger than 40 years (7) and the highest incidence rates being in older people. In the United Kingdom each year around 6 in 10 cases (61%) are diagnosed in people aged 70 years and over (8). There are no significant

sex differences in younger age groups: both men and women have a 0.03% likelihood of developing lung cancer up to the age of 39 (7). The incidence rates rise steeply around age 45–49 and peak in the 85–89 age group for males and in the 80–84 age group for females. The median age of diagnosis in the United States is 70 years and 68% of the patients are diagnosed after 65 years of age (1); 14% of lung cancers are diagnosed in patients older than 80 years (9). The incidence rates are higher for males than females in those aged 40–44 and from age 55–59. The widest gap appears at age 90 and more, when the male:female ratio is around 22:10 (8). The downturn observed at earlier ages in women reflects the fact that females have not yet reached the age of highest cancer incidence, since for lung cancer, incidence and mortality follow the trend of prevalence of cigarette smoking, with a latency of approximately 20 years (7).

Different ages require different considerations since age per se cannot be considered the unique variable to suggest or refuse surgical resection. However, decision making is extremely difficult in elderly patients, since this group is under-represented in clinical trials with only 25% of them

historically opening to patients older than 65 years (10).

Even biology of lung cancer may be heterogeneous in elderly patients, making a wider range of therapeutic options applicable. Frail elderly patients should be identified to assess those who will not benefit from surgery. However, definition of the functional status by standard preoperative assessment tools may not be reliable at advanced ages and new variables should be introduced to tailor the most adequate treatment strategy for each patient. Optimization of this strategy should allow decreasing cancer-related life limitations and letting median survival of elderly patients with cancer approach the normal life expectancy. So far, the life expectancy of an 80-year-old in the United States is 9.1 years (8.1 in males and 9.7 in females), while the median survival for elderly patients with untreated early-stage lung cancer is 14 months only (1,11). This suggests that life limitations in that group are purely cancer-related (12).

### Aging: physiologic changes

The respiratory system undergoes a number of structural, physiological and immunological changes with age. For this reason, at this stage of our life, it is not always easy to differentiate disease from a normal state.

The thoracic cage and diaphragm show important modifications with the aging process. The structural changes of the thoracic cage cause a marked reduction in terms of chest wall compliance. Osteoporosis results in a reduced vertebral height associated with a narrowing of the intervertebral disk spaces with consequent stiffness. Rib calcification and kyphosis reduces inspiratory expansion of the cage and places the diaphragm in an unfavorable setting for correct and effective contraction. The structural modifications are accompanied by the progressive atrophy with consequent weakness. The measurement of transdiaphragmatic pressure (TP), maximum voluntary ventilation (MVV) and maximum inspiratory pressure (MIP) reflects the contractile status of the diaphragm. All these variables decline with age (13-15), also the anatomical structure of the lung parenchyma changes. A progressive senile hyperinflation is observed (16) with enlarged air spaces, degeneration of the elastic fibers and reduction of the peribronchial support opposing to the premature closure of small airways during forced expiration and even normal breathing. This causes what is called "senile emphysema", with loss of elastic recoil, decreased lung compliance and intrapleural pressure. Changes in lung compliance are not uniformly distributed within the lungs with a consequent ventilation/perfusion mismatch (1).

From a functional point of view there is a decline in vital capacity (VC) and  $pO_2$  with increased residual volume (RV) both in smokers and non-smokers. The estimated rate of decline in forced expiratory volume in 1 second ( $FEV_1$ ) is 25-30 mL/year starting at the age of 35-40 years; it can even double up to 60 mL/year after 70 years of age (17). Also the diffusion capacity across the alveolar-capillary interface (DLCO) declines significantly (18).

The ventilatory response to lower oxygen tension and hypercapnic insults is markedly reduced during aging (19-21). The age-related beta-adrenergic receptor dysfunction causes older individuals to require lesser metacholine doses to cause significant bronchoconstriction when compared with middle-aged individuals.

Elderly patients are also at higher risk for respiratory tract infections due to impairment of the immune response (22). This risk is much higher in smokers due to bronchial mucociliary dysfunction (23,24).

Other age-related problems may be due to functional decline of other organs: decline in glomerular filtration rate, increasing incidence of heart disease and cognitive dysfunction, decrease of distribution of water-soluble drugs, assumption of more drugs with consequent potential side effects.

### General considerations

From the epidemiological point of view, early-stage lung cancer is observed more frequently in elderly patients; in fact, stage I disease increases from 79% in patients younger than 65 years to 87% in those above 75 years (25). Also resectability obviously increases with age (1,26): from 15.3% in those younger than 54 years to 25% above 75 years.

Also histology changes with age. Squamous cell carcinoma (SCC) increases from 27% in patients younger than 65 years to 38% in those above 75 years, with a decrease of adenocarcinoma from 61% to 50%. These modifications may be associated also to a different calculation of disease-free survival (DFS) since SCC is associated more frequently with local disease and lower recurrence rates (27-29).

Lobectomy associated with complete lymphadenectomy is considered the gold standard for lung cancer treatment (30), particularly for stage I and II disease (31). However, limited resections like wedges and segmentectomies have recently been reconsidered (32-34), particularly in the elderly and high-risk population. The previously well-documented overall survival benefits of lobectomy over limited resections are not observed in patients older than 75 years (25,35-37).

Razi clearly showed (38) that for T<sub>1</sub>AN<sub>0</sub>M<sub>0</sub> non-small cell lung cancer (NSCLC), sublobar resections are not inferior to lobectomy in the elderly population and they should be considered a viable alternative in this high-risk group. The thoracoscopic approach should also be incentivated since it not only contributes to reduce surgical trauma and preserve chest wall mechanics, but it also reduces postoperative morbidity and mortality, postoperative delirium, and it allows to lower the narcotic requirements and eventually favors a faster recovery time (11,39-42). If the thoracoscopic approach is not technically feasible, limited thoracotomy should be considered (43). Bronchovascular reconstructions should also be performed to avoid pneumonectomy (44-47), preserve lung function and reduce the rate of complications. Extended resections should be considered extremely carefully.

While surgery remains the treatment of choice for early stage lung cancer even in elderly patients, many of them are unsuitable for such an approach due to comorbidities or patient/relatives refusal. In these cases, standard external beam radiation and SBRT should be considered as an alternative after histological confirmation.

At an advanced age, the selection of patients fit for surgery is crucial. If preoperative work-up is inappropriate and operability is not assessed correctly, these patients could be under- or overtreated (48). The SEER database shows that only 8% of the youngest patients are denied surgery or offered a palliative treatment, in contrast to 30% of elderly patients (25). On the other side, if the selection is inappropriate, postoperative morbidity and mortality may raise dramatically. Aelony *et al.* (49) showed that for patients undergoing major lung resections for early stage NSCLC, mortality was 0.45% for those younger than 45 years and 1.2% for patients older than 75 years. Hino (50) showed that octogenarians with postoperative morbidity had significantly poorer prognosis than those without it. A number of risk factors for developing postoperative morbidity have been reported: congestive heart failure, myocardial infarction, male gender, type of operative procedure, extended lymph node dissection, FEV<sub>1</sub> of 40% or less, smoking status, stroke (3,26,27,42) and administration of induction therapy (51). For all these reasons, a “customized” preoperative assessment to identify physiological or pathological frailty should be encouraged since standard tools may be less reliable.

### Assessment of elderly patients before surgery

Elderly patients represent a heterogeneous group and they

should be accepted or not for lung surgery and other major surgical procedures on the basis of physiologic rather than chronologic age. Cardiac and pulmonary risk assessment should be included, as well as geriatric and cognitive evaluation.

Tumor boards provide a treatment planning approach with a number of clinicians of several specialties discussing the clinical status and treatment options for each patient. They are crucial to generate coordinated treatment plans and improve timely access to care (52); they allow better adherence to guidelines and help overcome the potential bias of the treating or diagnosing physician (53,54). These boards work not only as mechanisms for improving patient care but also as educational forums; particularly, they provide significant educational exposure for postgraduate trainees at University Institutions (55,56). The American College of Surgeons Commission on Cancer recognizes that they are essential for excellence in cancer care (5).

Cardiac evaluation: the American Heart Association (AHA) and the American College of Cardiology (ACC) have already provided guidelines for preoperative cardiovascular assessment for non-cardiac surgery at all ages (57). Six independent predictors of complications are currently considered (58):

- (I) High risk surgery (thoracic surgery is considered at high risk);
- (II) History of ischemic heart disease;
- (III) History of congestive heart failure;
- (IV) History of cerebrovascular disease;
- (V) Diabetes requiring treatment with insulin;
- (VI) Creatinine >2 mg/dL.

According to these variables, the incidence of major cardiac complications in the groups with 0, 1, 2 or 3 risk categories was 0.5%, 1.3%, 4% and 9% respectively.

Assessment for coronary risk factors and stress tolerance are crucial. Patients with a poor functional status or meeting at least one of the above mentioned criteria or with a history of angina or claudication should undergo noninvasive testing before surgery, including carotid artery echo. ECG and echocardiography should always be performed. An enlarged atrium has been reported to be a risk factor for the development of postoperative cardiac arrhythmia (59).

Pulmonary evaluation: pulmonary function tests (PFT) are always performed at any age before considering a patient as a suitable candidate for lung resection. Until a couple of decades ago standard spirometric variables were considered crucial; particularly, increased postoperative morbidity and mortality were predicted by a FEV<sub>1</sub> <2 L/sec or 60%

predicted for pneumonectomy, <1.6 L/sec for lobectomy and 0.6 L/sec for wedge resections and segmentectomy (60). More recently, the most commonly used functional algorithms for preoperative assessment suggest to consider the predicted post-operative (ppo) FEV<sub>1</sub> in choosing further tests or even excluding patients from operation without further tests (61). A value of ppoFEV<sub>1</sub> <40% is currently used to distinguish between normal risk and higher risk lung resection patients (62). However, ppoFEV<sub>1</sub> clearly overestimates the actual FEV<sub>1</sub> observed during the first postoperative period, when most of the complications are observed (63). Assessment of DLCO and VO<sub>2</sub>max may be required to further improve preoperative assessment (62).

Geriatric evaluation: a number of indices have been reported to be useful to assess the geriatric population; however, only two of them are particularly interesting and are currently considered. The International Society of Geriatric Oncology (ISGO) proposed the “Preoperative Assessment of Cancer in Elderly” (PACE) to assess surgical risk in this specific population. This tool includes several indexes [Eastern Cooperative Oncology Group (ECOG) performance status, American Society of Anesthesiologists (ASA) score, Physiologic and Operative Severity Score on the Enumeration of Mortality and Morbidity (POSSUM), activities of daily living (ADL), etc.]. This “score” has been validated in several branches of surgery but not yet in thoracic surgery (1).

The performance status as measured by the Karnofsky and the ECOG scales remain the most appropriate for patients with lung cancer undergoing surgery or not (64-67).

Cognitive evaluation: one of the most difficult variables to predict is the impact of surgery on functional decline/recovery and permanent loss of independence. Quality of life is extremely important both for patients undergoing surgery or medical treatment, including radiation; this is crucial for elderly patients and their families. There is not yet a decent amount of data in this specific subset of patients. Previous studies showed that most of the patients are discharged directly home from the hospital (68). Cognitive dysfunction is usually observed in 25% of the patients during the first week after surgery and 9% at 3 months. This increases with age (69). Patients with preoperative dementia are more likely to develop postoperative complications (70).

### Final considerations

The work already done to improve patient selection for lung surgery in the elderly population clearly shows that

surgical resection seems the treatment of choice for early stage lung cancer. Further studies are required to improve outcome by reducing postoperative morbidity and mortality.

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### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

### References

1. Bravo-Iñiguez C, Perez Martinez M, Armstrong KW, et al. Surgical resection of lung cancer in the elderly. *Thorac Surg Clin* 2014;24:371-81.
2. Kung HC, Hoyert DL, Xu J. Deaths: final data for 2005. Centers for Disease Control. *Natl Vital Stat Rep* 2008;56:1-124.
3. Vincent GK, Velkoff VA. The next four decades-the older population in the United States: 2010 to 2050. Current population reports. Washington, DC: US Census Bureau, 2010:25-1138.
4. Balducci L. Geriatric oncology: challenges for the new century. *Eur J Cancer* 2000;36:1741-54.
5. Mehta HJ, Ross C, Silvestri GA, et al. Evaluation and treatment of high-risk patients with early-stage lung cancer. *Clin Chest Med* 2011;32:783-97.
6. Extermann M. Measuring comorbidity in older cancer patients. *Eur J Cancer* 2000;36:453-71.
7. Smith PW, Jones DR. Biology and epidemiology of lung cancer. In: Patterson GA, Cooper JD, Deslauriers J, et al. eds. *Pearson's Thoracic and Esophageal Surgery*. 3rd Edition. Philadelphia, PA: Churchill Livingstone Elsevier, 2008:708-28.
8. Cancer research UK. Lung cancer incidence statistics. Accessed March 29, 2016. Available online: [www.cancerresearchuk.org](http://www.cancerresearchuk.org).
9. Owonikoko TK, Ragin CC, Belani CP, et al. Lung cancer in elderly patients: an analysis of the surveillance, epidemiology, and end results database. *J Clin Oncol* 2007;25:5570-7.
10. Hutchins LF, Unger JM, Crowley JJ, et al. Underrepresentation of patients 65 years of age or older in cancer-treatment trials. *N Engl J Med* 1999;341:2061-7.
11. McKenna RJ Jr. Thoracoscopic lobectomy with

- mediastinal sampling in 80-year-old patients. *Chest* 1994;106:1902-4.
12. Yellin A, Benfield JR. Surgery for bronchogenic carcinoma in the elderly. *Am Rev Respir Dis* 1985;131:197.
  13. Tolep K, Higgins N, Muza S, et al. Comparison of diaphragm strength between healthy adult elderly and young men. *Am J Respir Crit Care Med* 1995;152:677-82.
  14. Polkey MI, Harris ML, Hughes PD, et al. The contractile properties of the elderly human diaphragm. *Am J Respir Crit Care Med* 1997;155:1560-4.
  15. McClaran SR, Babcock MA, Pegelow DF, et al. Longitudinal effects of aging on lung function at rest and exercise in healthy active fit elderly adults. *J Appl Physiol* (1985) 1995;78:1957-68.
  16. Sharma G, Goodwin J. Effect of aging on respiratory system physiology and immunology. *Clin Interv Aging* 2006;1:253-60.
  17. Enright PL, Kronmal RA, Higgins M, et al. Spirometry reference values for women and men 65 to 85 years of age. Cardiovascular health study. *Am Rev Respir Dis* 1993;147:125-33.
  18. Stam H, Hrachovina V, Stijnen T, et al. Diffusing capacity dependent on lung volume and age in normal subjects. *J Appl Physiol* (1985) 1994;76:2356-63.
  19. Kronenberg RS, Drage CW. Attenuation of the ventilatory and heart rate responses to hypoxia and hypercapnia with aging in normal men. *J Clin Invest* 1973;52:1812-9.
  20. Rossi A, Ganassini A, Tantucci C, et al. Aging and the respiratory system. *Aging (Milano)* 1996;8:143-61.
  21. Janssens JP, Pache JC, Nicod LP. Physiological changes in respiratory function associated with ageing. *Eur Respir J* 1999;13:197-205.
  22. Meyer KC. Lung infections and aging. *Ageing Res Rev* 2004;3:55-67.
  23. Verra F, Escudier E, Lebargy F, et al. Ciliary abnormalities in bronchial epithelium of smokers, ex-smokers, and nonsmokers. *Am J Respir Crit Care Med* 1995;151:630-4.
  24. Salathe M, O'Riordan TG, Wanner A. Treatment of mucociliary dysfunction. *Chest* 1996;110:1048-57.
  25. Mery CM, Pappas AN, Bueno R, et al. 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* 2005;128:237-45.
  26. O'Rourke MA, Feussner JR, Feigl P, et al. Age trends of lung cancer stage at diagnosis. Implications for lung cancer screening in the elderly. *JAMA* 1987;258:921-6.
  27. Teeter SM, Holmes FF, McFarlane MJ. Lung carcinoma in the elderly population. Influence of histology on the inverse relationship of stage to age. *Cancer* 1987;60:1331-6.
  28. Weinmann M, Jeremic B, Toomes H, et al. Treatment of lung cancer in the elderly. Part I: non-small cell lung cancer. *Lung Cancer* 2003;39:233-53.
  29. Morandi U, Stefani A, Golinelli M, et al. Results of surgical resection in patients over the age of 70 years with non small-cell lung cancer. *Eur J Cardiothorac Surg* 1997;11:432-9.
  30. Ginsberg RJ, Rubinstein LV. Randomized trial of lobectomy versus limited resection for T1 N0 non-small cell lung cancer. Lung Cancer Study Group. *Ann Thorac Surg* 1995;60:615-22; discussion 622-3.
  31. Faulkner SL. Is lobectomy the "gold standard" for stage I lung cancer in year 2000? *Chest* 2000;118:119S.
  32. De Giacomo T, Di Stasio M, Diso D, et al. Sub-lobar lung resection of peripheral T1N0M0 NSCLC does not affect local recurrence rate. *Scand J Surg* 2009;98:225-8.
  33. Maurizi G, D'Andrilli A, Ciccone AM, et al. Margin Distance Does Not Influence Recurrence and Survival After Wedge Resection for Lung Cancer. *Ann Thorac Surg* 2015;100:918-24; discussion 924-5.
  34. Zhou H, Tapias LF, Gaisert HA, et al. Lymph Node Assessment and Impact on Survival in Video-Assisted Thoracoscopic Lobectomy or Segmentectomy. *Ann Thorac Surg* 2015;100:910-6.
  35. Okamoto J, Kubokura H, Usuda J. Factors Determining the Choice of Surgical Procedure in Elderly Patients with Non-Small Cell Lung Cancer. *Ann Thorac Cardiovasc Surg* 2016;22:131-8.
  36. Sancheti MS, Melvan JN, Medbery RL, et al. Outcomes After Surgery in High-Risk Patients With Early Stage Lung Cancer. *Ann Thorac Surg* 2016;101:1043-51.
  37. Dell'Amore A, Monteverde M, Martucci N, et al. Lobar and sub-lobar lung resection in octogenarians with early stage non-small cell lung cancer: factors affecting surgical outcomes and long-term results. *Gen Thorac Cardiovasc Surg* 2015;63:222-30.
  38. Razi SS, John MM, Sainathan S, et al. Sublobar resection is equivalent to lobectomy for T1a non-small cell lung cancer in the elderly: a Surveillance, Epidemiology, and End Results database analysis. *J Surg Res* 2016;200:683-9.
  39. DeCamp MM Jr, Jaklitsch MT, Mentzer SJ, et al. The safety and versatility of video-thoracoscopy: a prospective analysis of 895 consecutive cases. *J Am Coll Surg* 1995;181:113-20.
  40. Landreneau RJ, Hazelrigg SR, Mack MJ, et al. Postoperative pain-related morbidity: video-assisted

- thoracic surgery versus thoracotomy. *Ann Thorac Surg* 1993;56:1285-9.
41. Jaklitsch MT, DeCamp MM Jr, Liptay MJ, et al. Video-assisted thoracic surgery in the elderly. A review of 307 cases. *Chest* 1996;110:751-8.
  42. Cattaneo SM, Park BJ, Wilton AS, et al. Use of video-assisted thoracic surgery for lobectomy in the elderly results in fewer complications. *Ann Thorac Surg* 2008;85:231-5; discussion 235-6.
  43. Andreetti C, Menna C, Ibrahim M, et al. Postoperative pain control: videothoroscopic versus conservative mini-thoracotomic approach. *Eur J Cardiothorac Surg* 2014;46:907-12.
  44. D'Andrilli A, Maurizi G, Andreetti C, et al. Sleeve Lobectomy Versus Standard Lobectomy for Lung Cancer: Functional and Oncologic Evaluation. *Ann Thorac Surg* 2016;101:1936-42.
  45. Ricci C, Rendina EA, Venuta F, et al. Reconstruction of the pulmonary artery in patients with lung cancer. *Ann Thorac Surg* 1994;57:627-32; discussion 632-3.
  46. Rendina EA, Venuta F, Ciriaco P, et al. Bronchovascular sleeve resection. Technique, perioperative management, prevention, and treatment of complications. *J Thorac Cardiovasc Surg* 1993;106:73-9.
  47. Venuta F, Ciccone AM, Anile M, et al. Reconstruction of the pulmonary artery for lung cancer: long-term results. *J Thorac Cardiovasc Surg* 2009;138:1185-91.
  48. Samet J, Hunt WC, Key C, et al. Choice of cancer therapy varies with age of patient. *JAMA* 1986;255:3385-90.
  49. Aelony Y. Lung Resection in the Elderly. *Chest* 2006;129:496-7; author reply 497.
  50. Hino H, Murakawa T, Ichinose J, et al. Results of Lung Cancer Surgery for Octogenarians. *Ann Thorac Cardiovasc Surg* 2015;21:209-16.
  51. Venuta F, Anile M, Diso D, et al. Operative complications and early mortality after induction therapy for lung cancer. *Eur J Cardiothorac Surg* 2007;31:714-7.
  52. Gabel M, Hilton NE, Nathanson SD. Multidisciplinary breast cancer clinics. Do they work? *Cancer* 1997;79:2380-4.
  53. Abraham NS, Gossey JT, Davila JA, et al. Receipt of recommended therapy by patients with advanced colorectal cancer. *Am J Gastroenterol* 2006;101:1320-8.
  54. Lutterbach J, Pagenstecher A, Spreer J, et al. The brain tumor board: lessons to be learned from an interdisciplinary conference. *Onkologie* 2005;28:22-6.
  55. Petty JK, Vetto JT. Beyond doughnuts: tumor board recommendations influence patient care. *J Cancer Educ* 2002;17:97-100.
  56. Gatcliffe TA, Coleman RL. Tumor board: more than treatment planning--a 1-year prospective survey. *J Cancer Educ* 2008;23:235-7.
  57. Eagle KA, Berger PB, Calkins H, et al. ACC/AHA guideline update for perioperative cardiovascular evaluation for noncardiac surgery--executive summary a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1996 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). *Circulation* 2002;105:1257-67.
  58. Lee TH, Marcantonio ER, Mangione CM, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. *Circulation* 1999;100:1043-9.
  59. Anile M, Telha V, Diso D, et al. Left atrial size predicts the onset of atrial fibrillation after major pulmonary resections. *Eur J Cardiothorac Surg* 2012;41:1094-7; discussion 1097.
  60. Datta D, Lahiri B. Preoperative evaluation of patients undergoing lung resection surgery. *Chest* 2003;123:2096-103.
  61. Brunelli A, Charloux A, Bolliger CT, et al. ERS/ESTS clinical guidelines on fitness for radical therapy in lung cancer patients (surgery and chemo-radiotherapy). *Eur Respir J* 2009;34:17-41.
  62. Brunelli A, Refai MA, Salati M, et al. Carbon monoxide lung diffusion capacity improves risk stratification in patients without airflow limitation: evidence for systematic measurement before lung resection. *Eur J Cardiothorac Surg* 2006;29:567-70.
  63. Varela G, Brunelli A, Rocco G, et al. Predicted versus observed FEV1 in the immediate postoperative period after pulmonary lobectomy. *Eur J Cardiothorac Surg* 2006;30:644-8.
  64. Buccheri G, Ferrigno D, Tamburini M. Karnofsky and ECOG performance status scoring in lung cancer: a prospective, longitudinal study of 536 patients from a single institution. *Eur J Cancer* 1996;32A:1135-41.
  65. Harpole DH Jr, Herndon JE 2nd, Young WG Jr, et al. Stage I nonsmall cell lung cancer. A multivariate analysis of treatment methods and patterns of recurrence. *Cancer* 1995;76:787-96.
  66. Stamatis G, Djuric D, Eberhardt W, et al. Postoperative morbidity and mortality after induction chemoradiotherapy for locally advanced lung cancer: an analysis of 350 operated patients. *Eur J Cardiothorac Surg* 2002;22:292-7.
  67. Ferguson MK, Vigneswaran WT. Diffusing capacity

- predicts morbidity after lung resection in patients without obstructive lung disease. *Ann Thorac Surg* 2008;85:1158-64; discussion 1164-5.
68. Brock MV, Kim MP, Hooker CM, et al. Pulmonary resection in octogenarians with stage I nonsmall cell lung cancer: a 22-year experience. *Ann Thorac Surg* 2004;77:271-7.
69. Moller JT, Cluitmans P, Rasmussen LS, et al. Long-term postoperative cognitive dysfunction in the elderly ISPOCD1 study. ISPOCD investigators. International Study of Post-Operative Cognitive Dysfunction. *Lancet* 1998;351:857-61.
70. Fukuse T, Satoda N, Hijiya K, et al. Importance of a comprehensive geriatric assessment in prediction of complications following thoracic surgery in elderly patients. *Chest* 2005;127:886-91.

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