Predictors of postoperative decline in quality of life after major lung resections

Cecilia Pompili *, Alessandro Brunelli, Francesco Xiumé, Majed Refai, Michele Salati, Armando Sabbatini
Division of Thoracic Surgery, Ospedali Riuniti Ancona, Ancona, Italy

Received 26 May 2010; received in revised form 26 August 2010; accepted 30 August 2010

Abstract

Objective: Severe impairment in quality of life (QoL) is one of the major patients’ fears about lung surgery. Its prediction can be valuable information for both patients and physicians. The objective of this study was to identify predictors of clinically relevant decline of the physical and emotional components of QoL after lung resection. Methods: This is a prospective observational study on 172 consecutive patients submitted to lobectomy or pneumonectomy (2007—2008). QoL was assessed before and 3 months after operation through the administration of the Short Form 36v2 survey. The relevance of the perioperative changes in physical component summary (PCS) and mental component summary (MCS) scales was measured by the Cohen’s effect size (mean change of the variable divided by its baseline standard deviation). An effect size >0.8 is regarded as large and clinically relevant. QoL changes were dichotomized according to this threshold. Logistic regression and bootstrap analyses were used to identify reliable predictors of large decline in PCS and MCS. Results: A total of 48 patients (28%) had a large decline in the PCS scale and 26 (15%) in the MCS scale. Patients with a better preoperative physical functioning (p = 0.0008) and bodily pain (p = 0.048) scores and those with worse mental health (p = 0.0007) scores were those at higher risk of a relevant physical deterioration. Patients with a lower predicted postoperative forced expiratory volume in 1 s (ppoFEV1; p = 0.04), higher preoperative scores of social functioning (p = 0.02) and mental health (p = 0.06) were those at higher risk of a relevant emotional deterioration. The following logistic equations were derived to calculate the risk of decline in physical or emotional components of QoL, respectively: risk of physical decline: ln R/(1 + R): −11.6 + 0.19XPF, physical functioning + 0.05XBP, bodily pain − 0.05XMH, mental health; risk of emotional decline: ln R/(1 + R): −8.06 − 0.03XppoFEV1 + 0.11XSF + 0.05XMH. Conclusions: A consistent proportion of patients undergoing lung resection exhibit an important postoperative worsening in their QoL. We were able to identify reliable risk factors and predictive equations estimating this decline. These findings may be used as selection criteria for efficacy trials on perioperative physical rehabilitation or psychological treatments, during preoperative counseling, in the surgical decision-making process and for selecting those patients who would benefit from physical and emotional supportive programs.

Keywords: Quality of life; Pulmonary resection; Non-small-cell lung cancer

1. Introduction

The decision to proceed to surgery is often based on measurable physiologic parameters mainly associated with perioperative morbidity and mortality. Little attention in this regard is paid to the patients’ physical and emotional perceptions and expectations. However, what patients fear most about lung surgery, in most of the cases, is not much the risk of cardiopulmonary morbidity, but rather to be left physically and mentally handicapped and not be able anymore to resume a decent daily life style [1].

Although an abundance of risk models has been published to predict perioperative morbidity and mortality, scant information exists regarding the prediction of postoperative quality of life (QoL).

The objective of this investigation was to develop models predicting the risk of decline of physical and emotional components of QoL after lung resection.

2. Patients and methods

This is a prospective longitudinal study of 172 consecutive patients submitted to lobectomy (160 cases) or pneumonectomy (12 cases) from January 2007 to December 2008 for non-small-cell lung cancer (NSCLC) at a single center. QoL of all patients was assessed before (within 1 month of the operation) and after (3 months) the operation by the...
administration of the Short Form 36v2 (SF36v2) survey. The study was approved by the local Institutional Review Board of the hospital, and all patients gave their informed consent to participate. Postoperative early mortality was 1.1% (two patients) and the other 14 patients were not available for follow-up at 3 months; these patients were excluded from the analysis. Similarly, all those patients who submitted to extended procedures such as pleuropneumonectomy and chest wall or diaphragm resections were not included.

Operability exclusion criteria included a predicted postoperative forced expiratory volume in 1 s (ppFEV1) and predicted postoperative diffusion lung capacity for carbon monoxide (ppDLCO) below 30% of predicted value in association with a V̇O₂ peak (V̇O₂p, maximal oxygen uptake) lower than 10 ml kg⁻¹ min⁻¹. As a rule, all operations were performed through a lateral muscle-sparing, nerve-sparing [2] thoracotomy by board-certified thoracic surgeons.

Patients were extubated in the operating room and transferred to a dedicated thoracic ward. Postoperative management focused on early-as-possible mobilization, anti-thrombotic and antibiotic prophylaxis, and physical and respiratory rehabilitation. Thoracotomy chest pain was assessed at least twice daily and controlled through a systemic continuous infusion of non-opioid drugs. Therapy was titrated to achieve a visual analog score < 5 (in a scale ranging from 0 to 10) during the first 48—72 h. This regimen was usually switched to an oral therapy after removal of chest tubes. No formal preadmission or post-discharge physiotherapy or psychological supportive programs were administered.

Neurological or psychotropic personal medications, if present, were generally resumed the day following surgery.

QoL was assessed by the SF36v2 questionnaire [3], which is a generic instrument assessing eight physical and mental health concepts (PF, physical functioning; RP, role limitation caused by physical problems; BP, bodily pain; GH, general health perception; VT, vitality; SF, social functioning; RE, role limitation caused by emotional problems, and MH, mental health). Scores standardized to norms and weighted averages have a mean of 50 and a standard deviation of 10. As a consequence, all health dimensions and component scales, any score <50 falls below the general population mean and each point represents 1/10th of a standard deviation. This allows for a direct comparison of measures among different populations and scales.

2.1. Statistical analysis

The importance of the perioperative changes in physical and emotional composite scales (PCS and MCS) was measured by the Cohen’s effect size method (mean change of the variable divided by its baseline standard deviation) [4]. An effect size >0.8 is regarded as large and clinically relevant [5]. QoL changes were dichotomized according to this threshold (>0.8 or ≤0.8). Stepwise logistic regression analysis was used to identify reliable predictors of perioperative relevant decline in PCS and MCS (preoperative minus postoperative values effect size >0.8). The following variables were initially screened by univariate analysis to be included in the logistic regression: age, body mass index (BMI), forced expiratory volume in 1 s (FEV1), forced expiratory capacity (FVC), FEV1-to-FVC ratio, diffusion lung capacity for carbon monoxide (DLCO), ppFEV1 and ppDLCO, arterial oxygen and carbon dioxide tensions, preoperative hemoglobin level, smoking pack-years, American Society of Anesthesiology Score, Eastern Cooperative Oncology Group score, history of coronary artery disease (CAD), neoadjuvant chemotherapy, diabetes, type of operation (lobectomy vs pneumonectomy), the presence of peripheral vascular disease, history of cerebrovascular accident, and all eight individual QoL physical and emotional domains. Numeric variables were tested by using the unpaired Student’s t-test (normal distribution) or the Mann–Whitney test (non-normal distribution). Categorical variables were compared by the Chi-square test or the Fisher’s exact test as appropriate. Variables with a p < 0.1 at univariate analysis were used as independent predictors in two stepwise backward logistic regression analyses (dependent variables relevant decline of PCS or relevant decline of MCS, respectively). A p < 0.1 cutoff was used for retention of variables in the final model. Multicolinearity was avoided by using in the regression only one variable of a set of correlated variables (r > 0.5), which was selected by bootstrap technique.

Bootstrap analyses using 1000 samples of the same number of patients as the original dataset were used to assess reliability of the final models and predictors. In the bootstrap procedure, repeated samples of the same number of observations as the original database were selected with replacement from the original set of observations. For each sample, stepwise logistic regression was performed. The stability of the final stepwise model can be assessed by identifying the variables that enter most frequently in the repeated bootstrap models and comparing those variables with the variables in the final stepwise model. If the final stepwise model variables occur in a majority (>50%) of the bootstrap models, the original final stepwise regression model can be judged to be stable [6–8]. Statistical analysis was performed on the Stata 9.0 statistical software.

3. Results

The characteristics of the 172 patients included in this series are provided in Table 1. The average preoperative PCS and MCS values were 52.4 and 46.6, respectively. The average postoperative values of PCS and MCS were 49.7 and 48.2, respectively.

Compared with the average general population (score 50), 59 patients (34%) had a reduced (<50) physical composite scale before the operation and 85 (49%) after 3 months. Ninety-three patients (54%) had a depressed (<50) mental composite scale before surgery and 81 (47%) after 3 months. Forty-eight patients (28%) had a large decline in the physical composite scale and 26 (15%) in the emotional composite scale.
Table 1. Characteristics of the 172 patients in the study.

| Variable                   | Patients with PCS decline (48 cases) | Patients without PCS decline (124 cases) | p-value |
|----------------------------|--------------------------------------|------------------------------------------|---------|
| Age (years)                | 67 (27—84)                           | 68 (24—91)                               | 0.6     |
| BMI (kg/m²)                | 25.1 (17.3—35.4)                     | 25.7 (17—38)                             | 0.2     |
| FEV1%                      | 87 (50—142)                          | 83 (43—140)                              | 0.6     |
| FEV1/FVC ratio             | 0.72 (0.4—0.9)                       | 0.71 (0.5—0.9)                          | 0.2     |
| DLCO%                      | 81.5 (38—131)                        | 83.2 (37—107)                            | 0.4     |
| COPD (n, %)                | 18 (10%)                             | 19 (11%)                                 | 0.8     |
| Induction therapy (n, %)   | 18 (10%)                             | 19 (11%)                                 | 0.8     |
| CAD (n, %)                 | 19 (11%)                             | 19 (11%)                                 | 0.8     |
| Pneumonectomy (n, %)       | 12 (7%)                              | 14 (8%)                                  | 0.4     |
| ppoFEV1%                   | 69 (35—126)                          | 71 (38—128)                              | 0.4     |
| ppoDLCO%                   | 65 (28—107)                          | 66 (29—107)                              | 0.4     |
| Pack-years                 | 40 (0—160)                           | 40 (0—160)                               | 0.4     |
| ASA                        | 2 (1—3)                              | 3 (1—3)                                  | 0.4     |
| ECOG                       | 0 (0—2)                              | 0 (0—2)                                  | 0.4     |

Results are expressed as medians with ranges unless otherwise indicated. BMI: body mass index; CAD: coronary artery disease; COPD: chronic obstructive pulmonary disease; FEV1/FVC ratio: ratio of forced expiratory volume in one second to forced vital capacity; DLCO: diffusing capacity of the lung for carbon monoxide; COPD: chronic obstructive pulmonary disease; ASA: American Society of Anesthesiologists; ECOG: Eastern Cooperative Oncology Group; ppoFEV1: preoperative forced expiratory volume in one second; ppoDLCO: preoperative diffusing capacity of the lung for carbon monoxide.

Table 2 shows the results of the univariate comparison between patients with and without large decline of PCS. Table 3 shows the results of the univariate comparison between patients with and without large decline of MCS.

Variables with a p-value < 0.1 were used as independent predictors in logistic regression analyses, whose results are displayed in Table 4. Independent reliable predictors of physical decline included higher preoperative physical functioning (p = 0.0008) and bodily pain (p = 0.048) scores, and lower mental health (p = 0.0007) scores.

Most notably, the proportion of patients with a postoperative perceived physical decline was not influenced by the type of operation (pneumonectomy 33% vs lobectomy 28%, p = 0.8), age (elderly > 70 years of age 25% vs younger 31%, p = 0.5), chronic obstructive pulmonary disease (COPD) status (27% vs 28%, p = 0.8), or occurrence of postoperative complications (31% vs 27%, p = 0.5). Reliable predictors of emotional decline were a lower ppoFEV1 (p = 0.04), higher preoperative scores of social functioning (p = 0.02) and mental health (p = 0.06).

Similar to the physical component, the proportion of patients with a postoperative perceived emotional decline was not influenced by the type of operation (pneumonectomy 16% vs lobectomy 15%, p = 0.9), age (elderly > 70 years of age 16% vs younger 15%, p = 0.8), or COPD status (18% vs 13%, p = 0.3), but it was increased in those patients experiencing postoperative complications (24% vs 11%, p = 0.02). This last finding may be explained by a higher psychological burden caused by a longer postoperative stay and the need for more complex management.

The following logistic equations were derived to calculate the risk of decline in physical or emotional composite scales of QoL, respectively:

Risk of physical decline: \( \ln \frac{R}{1 + R} = -11.6 + 0.19 \times \text{PF} + 0.046 \times \text{BP} - 0.049 \times \text{MH} \)

(c-index 0.77; Hosmer—Lemeshow goodness-of-fit statistics 6.7, p = 0.6).

Risk of emotional decline: \( \ln \frac{R}{1 + R} = -8.06 - 0.03 \times \text{ppoFEV1} + 0.11 \times \text{SF} + 0.055 \times \text{MH} \)

(c-index 0.79, Hosmer—Lemeshow goodness-of-fit statistics 4.5, p = 0.8).

4. Discussion

Patient-centered outcomes are gaining importance in orienting health-care management. The focus of health-care providers and the public is gradually shifting from early postoperative endpoints (such as morbidity and mortality) to long-term outcomes (such as survival, residual function, and QoL). For decades surgeons’ attitude in evaluating surgical success has focused mainly on minimizing the risk of...
postoperative complications and death. This mentality has led to a physician-driven counseling system, often relegating the patients to a passive role. This has been the case particularly for subjects affected by a fatal disease, such as lung cancer, for which surgery may still represent the only chance of cure. The increased depression and tension-anxiety levels present in these patients compared with the general population [9] and the prospect of a cure may in fact lead them to totally rely on the physician’s clinical judgment.

Fortunately, in most recent years, this trend has changed and there is now a greater attention both to what patients really fear about their surgical experience and to the price they are willing to pay for increasing their chance of cure. Many of them are willing to accept even postoperative cardiopulmonary complications, but less so long-term functional disability [1]. For this reason, we as physicians should be willing to inform patients about their postoperative residual functional and emotional status.

Unfortunately, despite recent guidelines emphasizing the importance of this parameter [10], validated models to predict postoperative QoL are still lacking.

Therefore, the objective of this investigation was to develop equations to predict the risk of postoperative decline of physical and emotional components of QoL. The intent is twofold:

- to provide a specific tool for perioperative counseling, assisting in setting patients expectations about their surgical experience and
- to identify those patients at increased risk of QoL deterioration, who may benefit from perioperative and post-discharge physical and mental supportive programs.

QoL was assessed before and after operation by administering the SF36v2 questionnaire, which is one of the most-used instruments for evaluating physical and mental status of patients [3]. This generic type of health measure uses norm-based scores allowing the comparison of test results of a group in analysis to the general population mean and of scores of different groups of patients. Although other types of surveys exist and are probably more specific for pulmonary and neoplastic patients, the SF36 has a well-established

### Table 3. results of the univariate comparison between patients with and without perceived emotional decline (effect size > 0.8).

| Variables          | Patients with MCS decline (26 cases) | Patients without MCS decline (146 cases) | p-value |
|--------------------|-------------------------------------|----------------------------------------|---------|
| Age                | 65.7 (10.6)                         | 66.2 (10)                              | 0.9     |
| BMI                | 25.5 (3.6)                          | 25.5 (3.5)                             | 0.9     |
| PaO2               | 85.1 (20.8)                         | 80.7 (12.1)                            | 0.4     |
| PaCO2              | 39.2 (5.2)                          | 39.5 (7.8)                             | 0.9     |
| FEV1%              | 84.1 (18.1)                         | 90.3 (18)                              | 0.1     |
| ppoFEV1%           | 64.9 (14.6)                         | 71.3 (15.7)                            | 0.05    |
| FEV1/FVC ratio     | 0.71 (0.09)                         | 0.7 (0.09)                             | 0.8     |
| DLCO%              | 80.0 (16.9)                         | 82.4 (18.8)                            | 0.6     |
| ppoDLCO%           | 62.3 (13.4)                         | 65.1 (15.8)                            | 0.4     |
| CAD (n, %)         | 2 (8%)                              | 17 (12%)                               | 0.7     |
| Cerebrovascular accidents (n, %) | 3 (12%)                             | 8 (6%)                                 | 0.4     |
| Induction chemotherapy (n, %)     | 2 (8%)                              | 17 (12%)                               | 0.7     |
| Pneumonectomy (n, %)       | 2 (8%)                              | 10 (7%)                                | 0.9     |
| Preop SF36-PF       | 54.2 (4)                            | 51 (7.9)                               | 0.04    |
| Preop SF36-RP       | 47.3 (13.6)                         | 45.7 (12.2)                            | 0.3     |
| Preop SF36-BP       | 56.4 (9.7)                          | 54.5 (10.5)                            | 0.3     |
| Preop SF36-GH       | 50.5 (8.6)                          | 47.2 (8.8)                             | 0.06    |
| Preop SF36-VT       | 61.6 (7.2)                          | 55.3 (10.2)                            | 0.002   |
| Preop SF36-SF       | 55.4 (6)                            | 47.3 (11.3)                            | 0.0001  |
| Preop SF36-RE       | 52.7 (7.7)                          | 43.9 (14.8)                            | 0.005   |
| Preop SF36-MH       | 51.9 (8.4)                          | 44 (10.7)                              | 0.0005  |

Results are expressed as means ± standard deviations unless otherwise indicated. BMI: body mass index; CAD: coronary artery disease; SF36-PF: physical functioning; SF36-RP: role limitation caused by physical problems; SF36-BP: bodily pain; SF36-GH: general health perception; SF36-VT: vitality; SF36-SF: social functioning; SF36-MH: mental health.

### Table 4. Results of the backward stepwise logistic regression analyses. Two separate models (dependent variable model 1: decline in PCS; dependent variable model 2: decline in MCS). Parsimonious models displayed.

| Predictors | Coefficients | SE     | p-value | Bootstrap% |
|------------|--------------|--------|---------|------------|
| Intercept  | −11.6        | 3.1    |         | 99.9%      |
| Preop SF36-PF | 0.19        | 0.06   | 0.0008  | 63%        |
| Preop SF36-BP | 0.046       | 0.02   | 0.048   | 89%        |
| Preop SF36-MH | −0.049      | 0.02   | 0.007   | 89%        |

Model 2: decline in MCS

| Predictors | Coefficients | SE | p-value | Bootstrap% |
|------------|--------------|----|---------|------------|
| Intercept  | −8.06        | 2.8 |         | 66%        |
| ppoFEV1    | −0.032       | 0.02 | 0.04   | 82%        |
| Preop SF36-SF | 0.11       | 0.06 | 0.02   | 64%        |
| Preop SF36-MH | 0.055      | 0.03 | 0.06   | 64%        |

Bootstrap%: percentage of samples in which the specified variable turns out with p value lower than 0.1 in 1000 bootstrap samples. SF36-PF: physical functioning; SF36-BP: bodily pain; SF36-SF: social functioning; SF36-MH: mental health.
reliability and has been reported to be sensitive to postoperative changes after thoracic surgery for NSCLC [11].

We chose to re-assess the patients after 3 months with the main intent to limit the dropout rate and include the majority of patients undergoing major lung resections during that period. Longer follow-up has been associated with dropout rates as high as 40% in patients with lung cancer [12,13]. This would have inevitably determined a ‘cream-skimming’ effect with the best patients selected for evaluation.

Indeed, at 3 months, we already had 8% of patients lost at follow-up or who refused to be re-assessed.

Perioperative changes in physical and emotional composite scales were assessed by the Cohen’s effect size [4], a standardized mean difference scale-free statistics, providing a measure of separation between two group means. This parameter represents a standardized measure of the magnitude of the effect of an intervention, and it is particularly used in social and behavioral sciences.

According to the Cohen’s conventional criteria [5], an effect > 0.8 is defined as large. Accordingly, we chose this cutoff to dichotomize the perioperative decline in QoL.

Based on these criteria, we found that a considerable proportion of patients experience a large decline in physical and emotional components of their QoL compared with their preoperative status. Furthermore, compared with the general population, nearly half of the patients displayed a depressed physical and emotional status 3 months after surgery.

Although we were not able to find an association between decline in perceived physical status and preoperative physiologic parameters, specific QoL domains were found to be associated with this outcome. Patients with better preoperative physical functioning and bodily pain perception (less symptomatic) and those with worse mental health are those at higher risk of experiencing a large physical decline.

For instance, based on the logistic regression equation, a patient with preoperative SF36v2 norm-based PF and BP scores of 55 (falling above the general population mean of a half SD) and with an MH score of 45 (falling below the general population mean of a half SD) would have a risk of large physical decline of 31%.

The risk of perceived emotional decline was found to be greater in patients with lower ppoFEV1 and higher preoperative social functioning and mental health scores.

Based on the logistic regression equation, a patient with a preoperative ppoFEV1 of 50% along with SF and MH scores of 55 (falling above the general population mean of a half SD) would have a risk of large emotional decline of 38%.

In general, these findings confirm that patients reporting a better preoperative physical fitness, but with more compromised mental/emotional status, are those more prone to experience severe deterioration of their physical condition. It is likely that those patients with an impaired physical condition and with a more stable emotional status have lower expectations and are more prepared to be sick and face the challenges of a cancer operation. Similar findings were reported in the elderly when compared with younger patients [14,15]. Similarly, those patients feeling emotionally better before the operation are those experiencing the worst emotional decline, presumably because their expectations were higher than those with an already-compromised emotional status. In addition to mental-related scales of QoL, ppoFEV1 seems inversely related to decline in MCS in these patients.

Although comparison with previous investigations appears difficult due to a different methodology and design of the study, this is one of the rare circumstances in which an objective physiologic respiratory parameter is found to be associated with postoperative change in emotional status. Previous investigations have found these factors more related to physical components of QoL or global scores [15,16].

The study may have potential limitations:

- Similar to all longitudinal studies, we had dropouts (cancer recurrence, denial to take test, etc.). These patients may have been those in the worst conditions and their inclusion in the analysis may have influenced the results. This should be taken into account when interpreting this and other similar studies.
- QoL continues to improve up to 6–12 months [17,18]. Thus, extending the follow-up may have affected the results of this study and generalization of our models for longer-period evaluations need to be confirmed.
- Eighteen patients (10%) in this series underwent adjuvant chemotherapy. Although this factor has been shown by some to influence postoperative QoL [19], we decided to include these patients after a preliminary analysis showed no standardized mean difference in PCS or MCS values compared with those without chemotherapy.
- This analysis was performed by using the SF36v2 survey, a generic QoL instrument. Reproducibility of these results with other instruments needs to be verified.
- QoL may reflect patients’ perspective and may be affected by many external factors with an emotional impact such as type of information provided, radicality of the treatment, satisfaction with the provided care, and availability of family and social support. Further analyses are needed to include these factors in predictive models and assess their role in influencing residual QoL.

A consistent proportion of patients undergoing lung resection exhibit an important postoperative worsening in their QoL. We were able to identify reliable risk factors and predictive equations estimating this decline. These findings may be used as selection criteria for efficacy trials on perioperative physical rehabilitation or psychological treatments, during preoperative counseling, in the surgical decision-making process, and for selecting those patients who would benefit from physical and emotional supportive programs.

References

[1] Cykert S, Kissling G, Hansen C.J. Patient preferences regarding possible outcomes of lung resection. What outcomes should preoperative evaluations target? Chest 2000;117:1551–9.
[2] Cerfolio RJ, Bryant AS, Maniscalco LM. A nondivided intercostal muscle flap further reduces pain of thoracotomy: a prospective randomized trial. Ann Thorac Surg 2008;85:1901–7.
[3] Hays RD, Morales LS. The RAND-36 measures of health related quality of life. Ann Med 2001;33:350–7.

736 C. Pompili et al. / European Journal of Cardio-thoracic Surgery 39 (2011) 732–737
[4] Cohen J. Statistical power for the behavioral sciences, 2nd edition, Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.

[5] Valentine JC, Cooper H. Effect size substantive interpretation guidelines: issues in the interpretation of effect sizes. Washington, DC: What Works Clearinghouse; 2003.

[6] Blackstone EH. Breaking down barriers: helpful breakthrough statistical methods you need to understand better. J Thorac Cardiovasc Surg 2001;122:430–9.

[7] Grunkemeier GL, Wu YX. Bootstrap resampling method: something for nothing? Ann Thorac Surg 2004;77:1142–4.

[8] Brunelli A, Rocco G. Internal validation of risk models in lung resection surgery: bootstrap versus training and test sampling. J Thorac Cardiovasc Surg 2006;131:1243–7.

[9] Oh S, Miyamoto H, Yamazaki A, Fukai R, Shiomi K, Sonobe S, Saito Y, Sakuraba M, Fugagawa T, Sakao Y. Prospective analysis of depression and psychological distress before and after surgical resection of lung cancer. Gen Thorac Cardiovasc Surg 2007;55:119–24.

[10] Brunelli A, Charloux A, Bolliger CT, Rocco G, Sculier JP, Varela G, Licker M, Ferguson MK, Faivre-Finn C, Huber RM, Clini EM, Win T, De Ruyscher D, Goldman L, on behalf of the European Respiratory Society and European Society of Thoracic Surgeons joint task force on fitness for radical therapy. Eur Respir J 2009;34:17–41.

[11] Mangione CM, Goldman L, Orav EJ, Marcantonio ER, Pedan A, Ludwig LE, Donaldson MC, Sugarbaker DJ, Poss R, Lee TH. Health-related quality of life after elective surgery: measurement of longitudinal changes. J Gen Intern Med 1997;12:686–97.

[12] Markos J, Mullan BP, Hillman DR, Musk AW, Antico VF, Lovegrove FT, Carter MJ, Finucane KE. Pre-operative assessment as a predictor of morbidity and mortality after lung resection. Am Rev Respir Dis 1989;139:902–10.

[13] Bolliger CT, Jordan P, Soler M, Stulz P, Tamm M, Wyser C, Gonon M, Perruchoud AP. Pulmonary function and exercise capacity after lung resection. Eur Respir J 1996;9:415–21.

[14] Salati M, Brunelli A, Xiume F, Refai M, Sabbatini A. Quality of life in the elderly after major lung resection for lung cancer. Interact Cardiovasc Thorac Surg 2009;8:79–83.

[15] Ferguson NK, Parma CM, Celauro AD, Vigneswaran WT. Quality of life and mood in older patients after major lung resection. Ann Thorac Surg 2009;87:1007–12.

[16] Handy JR, Asaph JW, Skokan L, Reed CE, Koh S, Brooks G, Douville EC, Tseng AC, Ott GY, Silvestri GA. What happens to patients undergoing lung resection? Outcomes and quality of life before and after surgery. Chest 2002;122:21–30.

[17] Baldusky B, Hendriks J, Lauwers P, Van Schil P. Quality of life evolution after lung cancer surgery: a prospective study in 100 patients. Lung Cancer 2007;56:423–31.

[18] Schulte T, Schniewind B, Dohrmann P, Küchler T, Kudow R. The extent of lung parenchyma resection significantly impacts long-term quality of life in patients with non-small cell lung cancer. Chest 2009;135:322–9.

[19] Pauli DE, Thomas ML, Meade GE, Updyke GM, Arocho MA, Chin HW, Adebonojo SA, Little AG. Determinants of quality of life in patients following pulmonary resection for lung cancer. Am J Surg 2006;192:565–71.