Preoperative Pulmonary Evaluation for Lung Cancer Patients

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Abstract

Generally, two-thirds of all solid tumors occur in patients aged 65 or older and most deaths occur in this age group. Lung cancer is the second most common cancer in males in Jordan after colon cancer. Surgery continues to offer patients their best chance at curing this very aggressive disease. Thus, it is of extreme importance that patients receive full and comprehensive evaluations to risk- stratify them according to their postoperative risk of complications and that they are given every opportunity to undergo tumor resection. This can only be possible if patients are evaluated thoroughly and methodically. The methods used for this evaluation are simple, non-invasive and cost-effective. These methods are also readily available in Jordan. Spirometry, diffusing lung capacity, cardiopulmonary exercise testing and split lung evaluation must be conducted when indicated for all lung cancer patients. When performed appropriately, these tests will help direct patients to their indicated therapy. They will also help include all possible patients who may benefit from surgery with a net result of outcome improvement and cost reduction in health expenses that may arise from any unnecessary complications as a result of a suboptimum evaluation.

Keywords: lung cancer, spirometry, DLCO, cardiopulmonary exercise testing, split lung function.

(J Med J 2006; Vol. 40 (2): 121- 127)

Received	Accepted
March 6, 2006	March 29, 2006

Introduction

Surgery is the treatment of choice for lung cancer. Despite the encouraging developments in cancer therapy over the past years, lung cancer continues to have poor prognosis. [1] The five year survival for non small cell lung cancer is around 50%. The five year survival by clinical staging is between 60-70% for stage IA to 26- 35% for stage ШA. [2, 3]

As life expectancy improves and with no end in site to the tobacco epidemic, lung cancer incidence is expected to rise. Patients who undergo evaluation for lung cancer are often elderly, smokers and have co-morbidities. Therefore, the functional assessment of their cardiopulmonary reserve is of paramount importance.

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Not only will this help risk-stratify these patients according to their chances of developing postoperative complications, but it will also help provide the surgical option to more patients who were deemed inoperable based on suboptimal assessment. This article will review parameters used to preoperatively evaluate patients with non small cell lung cancer.

Non Pulmonary Parameters of Functional Operability Age

Age as a parameter must not be a reason to exclude patients from lung surgery. Careful evaluation of the patient's performance status and cardiopulmonary reserve must be conducted. Advanced age, more than 70 years, is associated with greater risk for complication as a result of other co- morbidities. However, lung cancer is not only the leading cause of cancer-related death in people older than 70 years in the western countries, [4] but also there is compelling evidence that patients with early stage lung cancer benefit from an aggressive surgical approach. Elderly patients have been reported to have earlier stage lung cancer at diagnosis than younger patients. [5] In addition, there is no difference in long- term survival in elderly patients who survive surgery compared with younger ones, but the older age group is less likely to be offered surgery. Therefore, elderly patients in a good state of health should not be excluded from surgery solely on the basis of their age. Every effort should be made to assess risk and optimize treatment for this expanding patient population. [6, 7]

Cardiac Risk

All elderly patients with lung cancer must undergo a detailed cardiac history and electrocardiogram (ECG). Those patients with no significant cardiac history and a normal ECG need no further evaluation. [7] Patients at risk for cardiac complications must undergo exercise stress testing to evaluate cardiac function. Patients with history of congestive heart failure or previous myocardial infarction should undergo echocardiography to evaluate ejection fraction. Myocardial infarction within the previous 3-6 months is associated with high operative risk. [8, 9]

Pulmonary Parameters of Functional Operability

Spirometry

Traditionally, forced expiratory volume in the first second (FEV_1) has been used to predict disease resectability. Literature suggest that preoperative FEV_1 (FEV_1-po) > 2 L is a safe limit for pneumonectomy and > 1.5 L for a lobectomy. [10- 12] The British Thoracic Society (BTS) data also suggest that the mortality rates in these cases will be < 5%. [13] This approach, however, does not take gender, height, weight and age into consideration. Smaller patients may tolerate lower levels of lung function. It, also, does not consider the functional state of the tissue to be removed. Using percent predicted data may be more accurate. Retrospective analysis of the BTS data suggest that an FEV_1 > 80% predicted indicates that the patient is suitable for a pneumonectomy without further evaluation, assuming the diffusing capacity of carbon monoxide (DLCO) is normal too. [14] Recently, and rightfully so, interest has shifted to estimate the predicted postoperative (PPO) remaining function of the lung. The techniques, discussed below, are used to estimate the FEV_1-ppo, DL_{CO}-ppo and maximal oxygen consumption on exercise testing (VO_2 max-ppo).

Diffusing Capacity

DLCO must be performed in lung cancer patients with undue dyspnea on exertion or evidence of interstitial lung disease on radiographic studies despite a normal FEV_1. Wyser et al. [14] demonstrated that patients with lung cancer and FEV_1 > 80% predicted and DL_{CO} > 80% predicted were all suitable for pneumonectomy. [14]

Values less than 60% of predicted are insufficient for major pulmonary resection [15] and less than 50% of predicted are considered risky. [16] In general, low DLCO is associated more frequently with pulmonary complications [15] and DL_{CO}-ppo should be considered as a predictor of postoperative complications. [17, 18] Neoadjuvent chemotherapy used in stage ШA lung cancer affects DLCO adjusted for lung volume (DLCO/VA). This was shown to be a sensitive risk indicator of respiratory complication after surgery. [19] It is important that DLCO studies are performed before and after chemotherapy in lung cancer patients undergoing induction therapy.

Split Function Studies, a Predictor of Postoperative Lung Function Values

Split function testing allows calculating the relative contribution of the tissue to be removed and estimating the PPO value. Many methods exist to calculate the FEV_1-ppo and DLCO-ppo. These vary from simply finding the predicted values from the remaining number of segments after resection to the sophisticated perfusion scans and quantitative computerized tomography scans.

The segment counting method is less accurate and should only be used when segments or subsegments are going to be resected. The formula to calculate the % FEV_1-ppo or % DLCO-ppo is: %PPO= preoperative %FEV_1-po × (No. of segments remaining/total No. of segments).

To calculate % DLCO-ppo simply substitute %DLCO-po in place of FEV_1-po. There are total 19 segments in the lung. 10 segments are present in the right lung; 3 in the upper lobe, 2 in the middle lobe and 5 in the lower lobe. 9 segments are present in the left lung; 3 in the upper lobe, 2 in the lingual and 4 in the lower lobe.

Perfusion Scan Versus Quantitative CT Scan

Scintigraphy using Tc-99 macroaggregated albumin is the current most widely used method to evaluate split lung function. [11, 14] By measuring the radioactivity count of the functional lung to be removed and comparing that to the radioactivity count of the total functional lung volume we can calculate the PPO lung function values from the following equation:

FEV_1- ppo= FEV_1- po × {1- (radioactivity count of the functional lung to be removed/ total radioactivity counts of both lungs)}.

Recently, quantitative computerized tomography has been shown to be a reliable and accurate method in estimating predicted post operative lung function values. [20] CT scan of the chest is the primary modality to stage non-small cell lung cancer. Quantitative CT scan does not require a separate procedure, saves time and avoids any further radiation exposure. Utilizing specialized software (Pulmo, Siemens) that can be uploaded on most CT scan machines, different attenuations in the lung and chest wall area could be outlined. Normal lung, emphysematous lung, tumor involved parenchyma, chest wall, heart and blood vessels all have different attenuation intensities (Fig.1). It takes the computer an average of 5 minutes to calculate the area of the functioning lung to be removed and the total functioning lung volume. Then, the following equation is used to calculate PPO lung function: FEV_1-ppo= FEV_1-po × {1-(functional lung volume to be removed/ Total functional lung volume)}.

Quantitative CT scan is also good at predicting patients with high risk post operative values such as FEV_1-ppo < 40%. However, due to more incidences of false-positive results which in return may preclude surgery on these patients, further careful evaluation using perfusion scan and Cardiopulmonary Exercise Testing (CPET) is warranted. [21] The above equation can be used to estimate DLCO-ppo and VO_2 max-ppo.

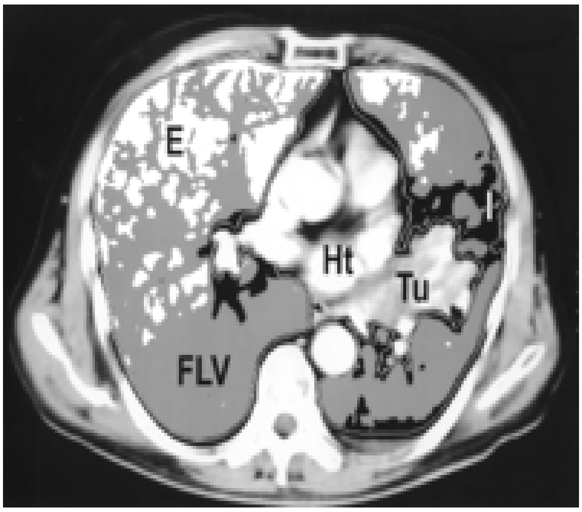

Fig.1: Assessment of fractional lung function by quantitative CT scan. Quantitative CT map shows "functional lung volume" of representative slice. Lung parenchyma was first outlined from mediastinum and chest wall (white-line contours). Tumor (Tu) was also excluded. White denoted emphysema (E), black area above denoted infiltration and atelectasis (I), and gray area between denoted functional lung volume (FLV).

Cardiopulmonary Exercise Testing

Cardiopulmonary Exercise Testing (CPET) provides a comprehensive assessment of systems that play a role in the overall body response to stress and exercise. These systems are often, sub optimally evaluated through the measurement of individual organ system function. CPET can evaluate the pulmonary, cardiovascular, hematopietic, neuropsychological and skeletal muscle systems. The importance of CPET stems from the fact that resting pulmonary and cardiac function cannot reliably predict exercise performance and functional capacity and that general health status correlates better with exercise tolerance rather than resting measures.

The body of evidence suggests that CPET and the measurement of VO_2max can predict postoperative pulmonary complications. [22, 23] CPET is indicated in all patients with an FEV_1 or a DLCO < 80%. When used simultaneously with split function studies, CPET will predict post operative functional capacity. This is of extreme importance in borderline patients who might otherwise be denied surgery. [23, 24] It is generally accepted that a VO_2max of 20 ml/Kg/min or more than 75% of predicted allows for a pneumonectomy, more than 15 ml/Kg/min is safe for a lobectomy and less than 10 ml/Kg/min or 40% predicted precludes any surgery [6, 25, 26] Morice et al [27] showed that in patients with FEV_1-ppo <33 %, eight patients underwent lobectomy because VO_2max > 15 ml/Kg/min was achieved, and no fatal complication occurred. Others showed that in patients with low % FEV_1-ppo and low % DLCO-ppo (both < 40% predicted) and VO_2max < 15 ml/Kg/min surgical risk was high. [28] This technology is currently available in Jordan and is highly recommended that it is used to its full capacity.

Arterial Blood Gas Measurement

Hypercapnia ($PaCO_2$ > 45 mm Hg) is not an independent risk factor for increased perioperative death. [29]

Traditionally, hypercapnia was used as exclusion criteria on the basis of its association with poor ventilatory function. [30] In two studies of lung cancer patients, perioperative complications were not higher in patients with preoperative hypercapnia. [31-33]

Perioperative hpoxemia, an arterial oxygen saturation < 90%, has been associated with increased risk of postoperative complication. In both cases, hypercapnia and hypoxemia the level of evidence is poor and further physiological testing like the ones mentioned above should be included before the final decision is made. [33]

Conclusion

Lung cancer is the second most common cancer in males in Jordan after colon cancer. [34] Until more aggressive measures are implemented to control teenage and passive smoking and more aggressive general public education campaigns conducted at schools, institutions and homes, this type of cancer and other smoking related cancers are expected to rise.

It is of paramount importance to optimally assess patients before surgery is provided (Fig. 2). Not only will this assure that the most cost effective therapy is delivered, but it will also guarantee that the right therapy is provided. This will in return reduce the burden on the health care system and improve the overall outcome of lung cancer in Jordan.

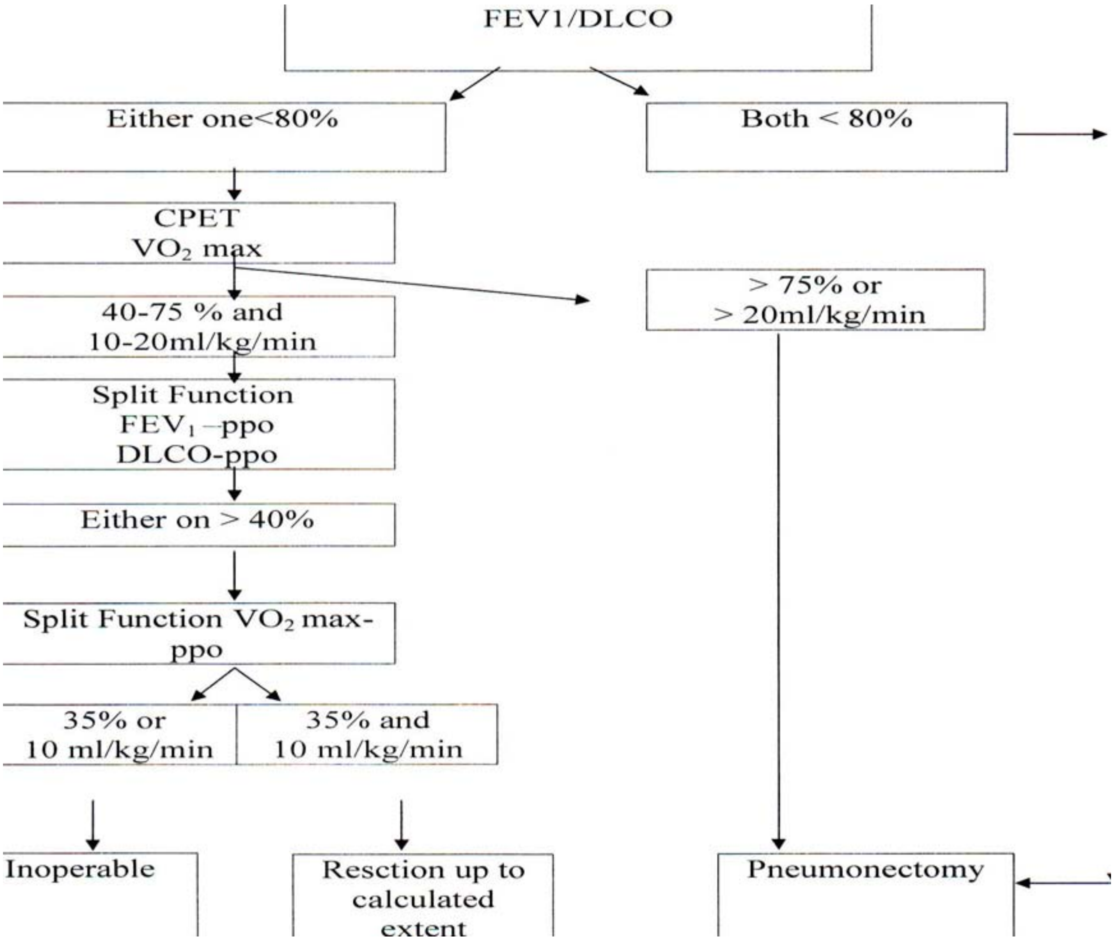

Fig.2: Algorithm for the assessment of the respiratory reserve in lung cancer patients. This flow chart shows the successive steps that must be taken to evaluate patients preoperatively for lung resection.

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