# PREOPERATIVE PULMONARY EVALUATION FOR PULMONARY AND EXTRAPULMONARY OPERATIONS

Filip Grubišić-Čabo[1], Ivo Grbac[1], Nikola Periša[2], Ksenija Kovačić[3], Davor Jurman[1] and Mladen Janaček[1]

[1]University Department of Pulmonology, [2]Department of Anesthesiology, [3]University Department of Oncology and Nuclear Medicine, Sestre milosrdnice University Hospital, Zagreb, Croatia

SUMMARY – The purpose of preoperative pulmonary assessment is to predict which patients are at greatest risk of pulmonary complications, under which circumstances such complications may occur, and whether surgery should be denied based on that risk. Surgical site is the most important predictor of pulmonary risk. The American College of Physicians suggest the following indications for preoperative pulmonary function tests: patients undergoing cardiac or upper abdominal surgery with a history of smoking or dyspnea, patients undergoing lower abdominal surgery if prolonged operation is anticipated, patients undergoing orthopedic surgery with uncharacterized lung disease, and all patients undergoing lung resection. These tests include spirometry, diffusing capacity for CO, arterial blood gases, symptom limited cardiopulmonary exercise testing, and quantitative differential lung perfusion scanning. None of these tests absolutely excludes a patient for surgery, however, they do identify patients at an increased risk of surgical morbidity and mortality.

Key words: *Lung, surgery; Lung, diagnosis; Respiratory function tests; Preoperative care; Risk factors*

## Introduction

The purpose of preoperative evaluation is not to 'clear' patients for elective operations but rather to evaluate and, if necessary, to implement measures to prepare high risk patients for the operation. The best therapeutic option for non-small cell lung cancer is surgical resection. Preoperative outpatient medical evaluation can decrease the length of hospital stay and minimize the rate of postponed or cancelled surgeries[1]. Surgical morbidity and mortality generally fall into one of three categories: cardiac, respiratory and infectious. Postoperative pulmonary complication is defined as an abnormality that produces identifiable disease or dysfunction which is clinically significant and adversely affects the clinical course. These include atelectasis, infection (including bronchitis and pneumonia), prolonged mechanical ventilation and respiratory failure, exacerbation of the underlying chronic lung disease, and bronchospasm.

Correspondence to: *Filip Grubišić-Čabo, M.D.*, University Department of Pulmonology, Sestre milosrdnice University Hospital, Vinogradska c. 29, HR-10000 Zagreb, Croatia

Received April 19, 2002, accepted in revised form June 11, 2003

## Perioperative Pulmonary Physiology

### *Respiratory effects of general anesthesia*

Anesthetic agents are associated with marked alterations in respiratory drive, i.e. a diminished response to both hypercapnia and hypoxemia. In combination with neuromuscular blockers, volatile anesthetic agents cause marked reduction in functional residual capacity due to diaphragm and chest wall relaxation, thereby decreasing thoracic volume. This decrease in lung volume induces atelectasis in the dependent lung regions persisting for more than 24 hours in 50% of patients. Consequently, arterial hypoxemia occurs from ventilation perfusion mismatch and increase in shunt fraction.

## Patient and Procedure Related Risk Factors

### *Patient related risk factors*

1) Age is not an independent risk factor for pulmonary complications.
2) Obesity increases the risk of postoperative pulmonary complications in patients undergoing abdominal surgery but may not be a risk in thoracic surgery.

3) General health status: ASA class and age are, however, too coarse as methods of evaluation for the individual risk and for giving judicious preoperative advice. Multifactorial cardiac risk indices such as that of Goldman allow for overall evaluation of preoperative cardiovascular risk in noncardiac operation, as a function of predictive clinical function elements[2].
4) Even in the absence of chronic obstructive pulmonary disease, current smokers have a twofold risk of postoperative complications.
5) Chronic obstructive pulmonary disease is one of the most important risk factors.

### *Procedure related risk factors*

1) Site of operation: the incidence of pulmonary complications is inversely related to the distance of surgical incision from the diaphragm.
2) Duration of operation: operations lasting for more than 3-4 hours have a higher incidence of pulmonary complications.
3) Type of anesthesia: a study of high risk patients showed the rate of respiratory failure to be significantly higher with general anesthesia. General anesthesia includes amnesia, analgesia and muscular relaxation[3].
4) Key hole surgery – laparoscopic abdominal surgery is associated with fewer postoperative pulmonary abnormalities and shorter hospital stay. Video-assisted thoracoscopic surgery utilizes much smaller incisions and the effects are similar to laparoscopic abdominal surgery considering possible pulmonary complications.

## Thoracic Surgery, Cardiac Surgery and Pulmonary Function Tests

Thoracopulmonary operations can be divided into the following categories:

1) operations of the thoracic wall (vertebral column, sternum, etc.);
2) operations of the pleura (decortications);
3) lung operations: (a) which improves lung function (bullectomy, volume reduction), and (b) with worsening of the lung function (tumor operations); and
4) operations of other organs within the thorax (esophagus, etc.).

### *Lung tumor operations*

Several clinical tests are used to determine operability in lung cancer patients. These tests include spirometry, diffusing capacity for CO (DLCO), arterial blood gases, symptom limited cardiopulmonary exercise testing, quantitative differential lung perfusion scanning, and right heart catheterization. The objective is to ascertain that after surgical resection of the lung for a tumor there will be sufficient pulmonary reserve to keep the patient comfortable and will not become a respiratory cripple. One should always evaluate the patient to determine whether he could withstand pneumonectomy even if radiologically only a lobectomy or limited resection is contemplated. On thoracotomy, the surgeon may be forced to do pneumonectomy because of an unexpected node over the pulmonary artery. Each segment contributes by approximately 5% to the pulmonary function. Spirometry provides the best objective measurement of airway obstruction. Epidemiologic evidence suggests that by the time FEV1 is appreciably reduced, there is usually extensive and symptomatic pulmonary pathology[4,5]. When FEV1 is more than *2* l, the risk of developing postoperative pulmonary complications is low. DLCO is used to measure gas exchange area and cross-sectional lung capillary area. Patients with predicted DLCO of less than 55% are at an increased risk of oxygen desaturation on exercise. Arterial blood gases are routinely measured in patients to undergo lung resection. If the patient's $CO_2$ retention is due to an obstructive defect, he is not considered a candidate for any lung resection. On the other hand, if $CO_2$ retention is due to causes other than obstruction, e.g., central hypoventilation, it is not a contraindication for surgery. If FEV1 is more than 1l, it is unlikely that $CO_2$ retention is due to obstructive defect. Spirometry, DLCO and arterial blood gases are good to test static pulmonary function and to identify resting gas exchange abnormalities. However, they do not provide any dynamic data on the patient's function. Cardiopulmonary exercise testing can provide such dynamic data. Oxygen consumption, $CO_2$ production, work rate and cardiac performance are measured during exercise. At maximal work rate, oxygen consumption is calculated and reported as ml of oxygen consumed *per* kg *per* minute. If patients are able to exercise at more than 15 ml/kg/min on several studies, their postoperative morbidity and mortality are low. If their maximal exercise capacity is less than 10 ml/kg/min, surgical morbidity and mortality are increased. The amount of perfusion to a lung area correlates well with that lung area's contribution to spirometry. In some patients, the diseased lung is the best lung. The best and most recent method of estimating split lung function is to perform quantitative V/Q scan. If the patient meets the following criteria, no further workup is required: FEV1 $>2$ l, FEV1/FVC $>50\%$, MVV $>50\%$ of predicted, and RV/TLC $<50\%$.

If FEV1 is less than 2 l, split lung function testing should be performed, e.g., FEV1 is 1.5 l: right lung perfusion is 30% and left lung perfusion is 70% (1.5x0.7=1.05), FEV1 after right pneumonectomy will be 1.05 l. If the predicted FEV1 is less than 800 ml, which is usually accepted as borderline, and if the surgeon still feels there is a resectable lesion with good prognosis, the next evaluation would be to occlude pulmonary artery and measure pulmonary artery pressure at rest and with exercise. If the pulmonary artery pressure is elevated at rest or on exercise, the patient is not a candiate for pneumonectomy. The patient obviously has no capillary bed reserve and is not able to tolerate the loss of vascular bed. He will develop cor pulmonale and the expected 5-year survival will be less than 50%. Complete resection of surgical stage I or II non-small cell lung cancer gives a predicted 5-year survival rate of approximately 70% and 50%, respectively, exclusive of operative mortality[6]. A multicenter study of more than 12000 thoracotomies assessed the incidence of in-hospital mortality for lung resection surgery. The in-hospital mortality rate was 3.8% after wedge resection, 3.7% after segmental resection, 4.2% after lobectomy, and 11.6% after pneumonectomy[7].

### *Cardiac surgery*

If the patient has unstable angina pectoris and significant left main or triple vessel stenosis, even the presence of global respiratory insufficiency is not an absolute contraindication for coronary artery bypass surgery. When pulmonary vascular resistance exceeds systemic by 50%, corrective operation for Eisenmenger's syndrome is contraindicated[8]. Atelectasis of the left lower lobe after cardiac surgery is such a common finding that some reviewers do not consider it a complication unless interfering with postoperative recovery and patient's discharge from the hospital. A damage to the phrenic nerve by use of ice slushes to decrease myocardial oxygen demand during surgery may be a major factor. Nerve injury may last from 30 days to as long as 2 years, and is commonly associated with elevated left hemidiaphragm.

## Abdominal and Other Sites of Surgical Procedures

### *Upper abdominal surgery*

The rate of pulmonary complications after surgery of the upper abdomen is as great as 20%, which is significantly more than that for surgery of the lower abdomen. The difference is in part due to the effect of the upper abdominal surgery on respiratory muscles. Liver transplantation is associated with a greater risk of postoperative pulmonary complications (infection and acute respiratory deficiency syndrome). Preoperative hypoxemia is often related to intrapulmonary vascular dilatations, which are best documented by perfusion lung scanning or contrast echocardiography that demonstrates shunting[9]. Since severe hypoxemia may pose an additional risk in these patients, a poor preoperative response to 100% oxygen may preclude transplantation. Laparoscopic surgery is associated with fewer postoperative pulmonary abnormalities and shorter hospital stay[10,11]. Although these procedures involve smaller incisions, the time of anesthesia is often longer.

### *Lower abdominal surgery*

A very low risk of pulmonary complications has been reported with surgery of the lower abdomen.

### *Extremity surgery*

An increased risk of postoperative deep venous thrombosis and pulmonary thromboembolism is found in patients undergoing orthopedic surgery to the lower extremity, where the incidence of lower extremity clotting approaches 50%-60%.

### *Neurosurgery and head and neck surgery*

Neurosurgical patients may have an altered mental status and decreased ability to cough, which would lead to lower tidal volumes and an increased risk of aspiration of oral contents. Surgical procedures of the head and neck for nonmalignant conditions, however, are not associated with increased pulmonary morbidity or mortality. Anatomic alterations of the upper airways after radical oncosurgical operations may predispose these patients to aspiration of saliva or food.

## Conclusion

To be certain that patients undergoing elective surgery are optimally managed from the pulmonary standpoint, all patients should have careful general history and physical examination focused on eliciting complaints and identifying signs of a disease that might alter their surgical risk. As some patients with increased pCO2 values and obstructive lung disease can undergo coronary artery bypass surgery and other major procedures successfully, this contraindication is not absolute, except for patients having lung resection. Hypoxemia is not a consideration. It is quite

possible that pO2 levels improve following intrapulmonary tumor resection. Individualized approach regarding the operation is preferred, also taking the patient's will in account.

## References


1. MACPHERSON DS, LOFGREN RP. Outpatient internal medicine preoperative evaluation: a randomized clinical trial. Med Care 1994;32:498-500.
2. PINAUD M. Evaluation of the cardiac risks in non-cardiac surgery in patients with heart failure. Arch Mal Coeur Vaiss 2002;95:(5 Spec 4):31-6.
3. MORGAN EG Jr, MAGED MS. Clinical anesthesiology. Stanford: Appleton, 1996.
4. BECKLAKE MR, PERMUTT S. Evaluation of tests of lung function for 'screening' for early detection of chronic obstructive lung disease. In: MECKLEM PT, PERMUTT S, eds. The lung in the transition between health and disease. New York: Marcel Dekker, 1979:345-87.
5. COSIO M, GHEZZO H, HOGG JC, *et al.* The relationship between structural changes in small airways and pulmonary function tests. N Engl J Med 1978;298:1277-81.
6. GASS GD, OLSEN GN. Preoperative pulmonary function testing to predict postoperative morbidity and mortality. Chest 1986;89:127-35.
7. ROMANO PS, MARK DH. Patient and hospital characteristics related to in-hospital mortality after lung cancer resection. Chest 1992;101:1332-7.
8. DRINKOVIĆ N. Kongenitalne srč9. ane greške. In: VRHOVAC B, *et al.*, eds. Interna medicina. Zagreb: Naprijed, 1997:630-7.
10. O'BRIEN JD, ETTINGER NA. Pulmonary complications of liver transplantation. Clin Chest Med 1996;17:99-114.
11. MEYERS WC. Southern Surgeons Club: a prospective analysis of 1518 laparoscopic cholecystectomies. N Engl J Med 1991;324:1073-8.
12. FRAZEE RC, ROBERTS JW, OKESON GC, *et al.* Open *versus* laparoscopic cholecystectomy. Ann Surg 1991;213:651-4.


Sažetak

PRIJEOPERACIJSKA PULMOLOŠKA OBRADA KOD PLUĆNIH I IZVANPLUĆNIH OPERACIJSKIH ZAHVATA

*F. Grubišić-Čabo, I. Grbac, N. Periša, K. Kovačić, D. Jurman i M. Janaček*

Svrha prijeoperacijske pulmološke obrade je predvidjeti koji bolesnici imaju najveći rizik od nastanka plućnih komplikacija, pod kojim okolnostima takve komplikacije mogu nastati i treba li operaciju otkazati zbog rizičnosti samoga zahvata. Najvažniji prediktor pulmonalnog rizika je lokacija operacijskog reza. Američka liječnička udruga preporuča slijedeće indikacije za prijeoperacijsku funkcijsku obradu pluća: bolesnici u kojih se planira operacija srca ili gornjeg abdomena s anamnezom pušenja ili zaduhe, bolesnici u kojih se planira operacija na donjem dijelu trbuha ako se predviđa dugotrajni zahvat, bolesnici s neodređenom plućnom bolešću u kojih se planira ortopedska operacija, te svi bolesnici u kojih se planiraju resekcijski zahvati na plućima. Funkcijske plućne pretrage obuhvaćaju spirometriju, difuzijski kapacitet za CO, arterijsku plinsku analizu, simptomima ograničene kardiopulmonalne stres testove, kvantitativnu diferencijalnu plućnu perfuziju. Prednost se daje individualnom pristupu glede operacije, poštivajući pritom i volju bolesnika.

Ključne riječi: *Pluća, kirurgija; Pluća, dijagnostika; Funkcijske plućne pretrage; Prijeoperacijska skrb; Rizični čimbenici*