Preoperative Evaluation of Patients Undergoing Lung Resection Surgery

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Introduction

- Advances in surgical and anesthetic techniques have resulted in a marked reduction in postoperative complication.
- Preoperative PFT evaluation is an integral part.
- About 30,000 lung resections are performed annually in the USA.
Commonly performed surgeries for lung cancer

- Pneumonectomy
- Lobectomy
- Wedge Resection
- Segmentectomy
Indications for Pulmonary Resection

- Neoplastic Disease
  - Primary
  - Metastatic
- Bullous Lung Disease: LVRS
- Diagnosis & Management of inflammatory conditions
  - Granulomas
  - Pulmonary infiltrates
  - Resection of segments destroyed by bronchiectasis

(Debnathva D et al. CHEST 2003;123:2096–2103)
Complications after thoracic surgery

Most Common
- Pneumonia
- Atelectasis
- Arrhythmias (AF)
- CCF

Less common
- MI
- Prolonged air leak
- Empyema
- Bronchopleural fistula
Mortality Rates

- Pneumonectomy: 6.8%
- Bi-lobectomy: 4.4%
- Lobectomy: 3.9%
- Lesser Resection: 1.4%

(Damhuis et al., Eur Respir J 1996; 9:7–10)
Postoperative complication of pulmonary resection

- Pneumonectomy-39%
- Lobectomy-19%
- Wedge resection-6%
<table>
<thead>
<tr>
<th>Changes in Lung Volume</th>
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<tbody>
<tr>
<td><strong>Pneumonectomy:</strong></td>
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<tr>
<td>* FEV1 reduced by 34- 36%</td>
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<tr>
<td>* FVC reduced by 36 - 40%</td>
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<td>* VO2 max reduced by 20 - 28%</td>
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Risk assessment for pulmonary surgery

High risk:
- Age >70
- Higher extent of resection
  (Pneumonectomy > lobectomy > resection)
- Poor exercise performance
- Low PPO FEV1
- Low PPO DLco
- High Pco2 (controversial)
- Prolong operative time
Risk assessment for pulmonary surgery

Low risk

- FEV1 > 2 L for pneumonectomy, > 1 L for lobectomy, > 0.6 L for segmentectomy
- PPO FEV1 > 30-40% predicted
- Stair climbing > 5 floor for pneumonectomy, 3 floor for lobectomy
- PPO DLco > 40% predicted
- Vo2max uptake > 15-20 ml/kg/min
Indications for pre-operative assessment

- To make a decision whether patient can tolerate surgery “pulmonary clearance”
- To predict the occurrence of post operative respiratory complications
- To assess the postoperative respiratory disability

(Pulmonary function tests in health and disease by Prof S K Jindal)
Minimal respiratory evaluation

- Good history taking
- Physical examination
- Chest roentgenography
- PFT
Important components of history in preoperative evaluation

- Presenting symptoms
- Prior diagnosis of pulmonary or cardiac disease
- Co-morbid conditions: DM, LD, RD
- Prior experiences with GA/Surgery
- Cigarette smoking: never/current/ex
- Medication/allergies
- Alcohol use, history of withdrawal syndrome
Preoperative Evaluation

Who should be evaluated?

The general answer

*All patients* undergoing lung resection surgery, irrespective of age or extent of the lesion.
Pulmonary-Specific Evaluation

- There is no single measure that is a "gold standard" in accurately predicting complications.

- However, certain criteria, when applied have been shown to be predictive of outcome.

(Debapriya D et al. CHEST 2003;123:2096–2103)
Stepwise approach of evaluation

Routine PFTS → FEV1 > 60%, DLCO > 60%

FEV1 < 60%, DLCO < 60%

Quantitative Lung Scan → PPO-FEV1 > 40%
PPO-DLCO > 40%

PPO-FEV1 < 40% / PPO-DLCO < 40%

EXERCISE TESTING → VO2max > 15ml/kg/min

VO2max < 15ml/kg/min → Other Options prior to attempting Surgery
Smoking

- Smoking is a risk factors for the development of post operative complication
- Relative risk of complication after surgery for smoker 1.4 to 4.3 fold.
  
  (Smetana GW et al., N eng J Med 1999;340:937-944)
- Smoking cessation decreased postoperative pulmonary complication
- Recommendations- Surgery should be delayed for 8 weeks after smoking cessation
Pulmonary-Specific Evaluation

Pulmonary Function Tests Include:

- Spirometry
- Lung Volumes
- Diffusion Capacity
- Arterial Blood Gas Analysis
- Radionuclear Lung Scanning
- Cardiopulmonary Exercise Testing
Stages of Pulmonary-Specific Evaluation

Stage I Assessment (Preop lung function)
* Spirometry
* Arterial Blood Gas Analysis
* DLCO

Stage II Assessment (Postop lung function)
* Quantitative Ventilation-Perfusion Scan
* Quantitative CT Scan

Stage III Assessment
* Exercise Testing: Oxygen Uptake (VO2 Max)

(Debapriya D et al. CHEST 2003;123:2096–2103)
Stage I Spirometry:

- Simple, inexpensive, standardized & readily available
  - FVC → reflect lung volume
  - FEV1, FEF25–75% → reflect airflow
  - MVV → Muscle Strength
- Predicted values of pulmonary function depend on age, height, gender and race
  (*Debapriya D et al. CHEST 2003;123:2096–2103*)
- Spirometry can provide cut-off values of acceptable risk in patients for thoracic surgery
Stage- I (Spirometry)  FEV1

- Preop. FEV1 <60% of predicted, Strongest predictor of postope. complications
- ACCP & BTS Guidelines:
  - FEV1 > 2 L tolerate pneumonectomy
  - FEV1 > 1-1.5 L tolerate lobectomy
  

- Postope. pulmonary complication in patients with FEV1<2L was 40% VS 19% for those with FEV1 >2L
  
  (Stephan MK et al. Chest 2000;118:1263-1270)
Stage- I (Spirometry)  FEV1

BTS Guidelines compiled on data from >2000 patients in 3 large series
Mortality Rate < 5%

- FEV1 > 1.5 L for Lobectomy
- FEV1 > 2 L or > 80% predicted for Pneumonectomy

(Beckles MA et al., CHEST 2003; 123:105S-114S)
Stage- I DLCO

- Reflects alveolar membrane integrity & pulmonary capillary blood flow in the patient’s lungs
- Was the most important predictor of mortality & was the sole predictor of postoperative pulmonary complications
- Equally significant predictor of postoperative complications as FEV1

(Debapriya D et al., CHEST 2003;123:2096–2103)
Stage- I DLCO

- Routine measurement of DLCO in all candidates for lung resection, irrespective of their FEV1 value, in order to improve surgical risk stratification
  
  *(Brunelli A et al., Eur J Cardiothoracic Surg 2006;29;567-70)*

- DLCO < 60% predicted associated with ↑ mortality.

- DLCO & FEV1 should be viewed as complementary physiologic tests

  *(Beckles MA et al., CHEST 2003; 123:105S-114S)*
Stage I
Arterial Blood Gas Analysis (ABG)

- Not extensively studied as predictor of postoperative complication
- PCO2 >50 mm Hg - traditional contraindication to lung resection
- But in recent studies
  Patients with a PCO2 of 45 mm Hg did well postoperatively
  Was not predictive of postoperative complications

(Debapriya D et al. CHEST 2003;123:2096–2103)
Stage I
Arterial Blood Gas Analysis (ABG)

- Preoperative PCO2 < 45 mmHg vs. PCO2 > 45 mmHg, postoperative complications 17% vs. 13%
- Hypoxemia (SaO2 < 90%) was associated with ↑ risk of postoperative complications

(Kearney DJ et al., Chest 1994;105:753-759)
Stage-I (Spirometry) Recommendation

- Pneumonectomy
  MVV > 55% of predicted, FEV1 > 2 L, FEF25–75% > 1.6 L/s.
- Lobectomy
  MVV > 40% of predicted, FEV1 > 1 L, FEF25–75% > 0.6 L/s.
- Segmentectomy or Wedge Resection
  MVV > 40% of predicted, FEV1 > 0.6 L, FEF25–75% > 0.6 L/s

Stage-I (Spirometry)
Criteria of increased postoperative complications and mortality

Pneumonectomy:
FEV1 < 2L or 60% of predicted, MVV < 55% of predicted,
DLCO < 50% of predicted, FEF25–75% < 1.6L/s.

Lobectomy:
FEV1 < 1 L, MVV < 40% of predicted,
FEF25–75% < 0.6 L/s, DLCO < 50% of predicted.

Wedge resection/Segmentectomy:
FEV1 < 0.6 L, DLCO < 50% of predicted.

(Stephan F et al., Chest 2000; 118:1263–1270)
Stage-II Assessment

Consist of measurement of individual lung function (Regional lung function)

- Quantitative V/Q scan
- Bronchspirometry
- Lateral position testing
- Quantitative CT scanning
Stage-II
Indication of regional lung function

- Significant airflow obstruction
  - $\text{FEV}_1 < 65\%$ predicted
  - $\text{FEV}_1/\text{FVC} < 0.70$
- Significant pleural disease
- Known and suspected endobronchial obstruction
- Central lung mass
- History of prior lung resection
Stage-II
Quantitative Ventilation-Perfusion Scan:

- Measures predicted Postoperative lung function
- Readily available with negligible risk
- Highly accurate in the prediction of postoperative pulmonary function following resection
- Inhaled 133Xe or IV 99Tc

(Jeng-Shing Wang et al., Resp Med 2004; 98:598-605)
Stage II
Inhaled 133Xe or IV 99Tc

- % of radioactivity contributed by each lung correlates with the contribution of the function of that lung
- Normally: 19 Segments (10 R & 9 L)
  - Right Lung (3/2/5): 55 % & Left Lung(3/2/4): 45%
- Calculation: 1
  - PPO FEV1:-Preope.FEV1X % of radioactivity contributed by nonoperated lung

(Kristersson et al., Chest 1972;62:696-698)
Stage-II

● **Calculation-2**

Expected loss of function = Preop. FEV1 × % of function of affected lung

\[
\text{No. of segments in lobe to be resected} \times \frac{\text{total No. of segments in the whole lung}}{100}
\]


● **Juhl formula for PPO FEV1**

\[
\text{PPO FEV1} = \text{preopr.FEV1} \times (1 - \frac{\text{S} \times 0.25}{100})
\]

S = No of BPS involved

(Juhl B, Frost B *Acta anaesthesiol Scand* 1975; 49:8-13)
Stage-II

Using 133Xe Inhalation:
- PPO FEV1 of < 1 L is indicative of physiologic inoperability.

Using 99Tc Macroaggregate of Albumin Perfusion:
- PPO FEV1 of < 0.8 L is indicative of surgical inoperability.
- More widely accepted formula by Kristersson/Olsen formula for PPO FEV1
  (Sietske A et al. CHEST 2004; 125:1735–1741)
Stage-II
Predictors of Morbidity & Mortality after lung resection

- PPO FEV1 < 40% of predicted - 50% ↑Mortality
- PPO FEV1 > 40% of predicted - 50% ↓Mortality
- PPO DLCO < 40% of predicted - ↑Mortality

Stage-II
Recommendation

- If PPO FEV1 >40% and PPO DLCO > 40% - allowed to surgery

- If PPO FEV1<40% and PPO DLCO<40% need further evaluation

Stage-II

Other Tests:

- Bronchspirometry, Lateral position testing & Total Unilateral pulmonary artery occlusion
- Invasive tests & Require specialized equipment with a high level of technical expertise
- These test are no longer performed in the preoperative evaluation of patients awaiting lung resection

(Debapriya D et al., CHEST 2003;123:2096–2103)
Stage-III Assessment
Cardio-Pulmonary Exercise Testing

- Indicated when PPO FEV1 < 35 to 40% and DLCO < 40% of predicted
- Stresses the entire cardiopulmonary & oxygen delivery system
- Provides a good estimate of cardiopulmonary reserve
- Pulmonary/cardiac function & peripheral oxygen utilization
Stage-III Assessment (CPET)

Measurement of exhaled gases
- Oxygen uptake (Vo2)
- Maximal Vo2 (Vo2max)

Formula for estimating Vo2
Predicted Vo2 = 5.8xwt.in kg + 151 + 10.1(W of workload)
Stage-III (CPET)

- **VO2max**
  
  With increasing muscular work VO2 rises to a point where there is a plateau of the VO2 work rate slope.

- **VO2 max** is a measure of aerobic capacity of the peripheral tissue (Oxygen Consumption)

Stage-III Assessment (CPET)

3 major types of tests

- Fixed exercise challenge
  (Sustained level of work)
- Incremental exercise challenge
  (Work rate is sequentially increased to a desired end point)
- Submaximal vs. Maximal oxygen consumption (VO2 Max)

(Debapriya D et al., CHEST 2003;123:2096–2103)
Stage-III(CPET)
Fixed Challenge Exercise Testing

- Climbing a certain number of stairs
- Walking a fixed distance

- Patients who able to climb up to three floor (i.e. 75 steps) had ↓ number of postoperative complications
  
  (Olsen GN et al., Chest 1991; 99:587–590)

- Prospective study of 16 patients 6-min walk distance > 1000 feet & Stair climb of > 44 steps, Successful surgical outcome
  
  (Holden DA et al., Chest 1992; 102:1774–1779)
Stage-III(CPET)  
Fixed Challenge Exercise Testing

Prospectively evaluated of 83 patients, complications occurred:
- Who unable to climb one floor- 89%
- Who unable to climb two floor- 80%
- Inability to climb 5 floor- 32%
- Who could climb 7 floor- No complications

(Girish M et al. Chest 2001;120:1147-1151)
Stage-III (CPET) Incremental Exercise Testing

Measurement VO2 max in patients for lung resection
- VO2 Max > 1 L/min → No mortality
- VO2 Max < 1 L/min → 100% mortality


Incidence of Postoperative complications
- VO2 Max < 15 mL/kg/min → 100% complication rate
- VO2 Max 15-20 mL/kg/min → 66% complication rate
- VO2 Max > 20 mL/kg/min → 10% complication rate

(Smith TP et al., Am Rev Respir Dis 1984; 129:730–734)
Conclusions

- Patients with thoracic surgery should undergo evaluation for surgical resectability
- Patients with FEV1 and DLco >60% of predicted can be referred for surgery without undergoing other tests
- Patients with preoper. FEV1 and DLco <60% of predicted need further evaluation
- Quantitative V/Q lung scan is done to estimate PPO FEV1 and DLco
Conclusions

- If the PPO FEV1 and DLco are 40% of predicted, surgical risk is acceptable.
- Patients with PPO FEV1 and DLco <40% should undergo exercise testing to evaluate pulmonary reserve and to assess the adequacy of oxygen transport.
- Cycle ergometry with incremental workloads, which can measures Vo2, Vo2max.
Conclusions

- Patients with Vo2max < 10 ml/kg/min. should not undergo lung resection surgery.

- Patients with PPO FEV1/ DLco < 40% of predicted, but Vo2max > 15 mL/kg/ min, can undergo surgical resection, including pneumonectomy.
THANK YOU