Preoperative Pulmonary Evaluation for Lung Resection
Outline of Discussion

- Objectives of preoperative pulmonary evaluation of patients for surgical resection
- Use of predicted postoperative pulmonary function parameters to identify patients at increased risk for complications after lung resection
- Prediction of postoperative pulmonary function by technique of simple calculation and use of lung perfusion scan
- Algorithm for preoperative evaluation of patients for lung resection
Reduction of Pulmonary Function after Resection

Across various studies, postoperative pulmonary function values were assessed at various time intervals after lobectomy or pneumonectomy:

- **FEV1:**
  - 84% - 91% of preoperative values for lobectomy,
  - 64% - 66% for pneumonectomy

- **DLCO:**
  - 89% - 96% of preoperative values after lobectomy
  - 72% - 80% after pneumonectomy

- **VO₂ max:**
  - 87% - 100% of preoperative values after lobectomy
  - 71% - 89% after pneumonectomy

Why do we do preoperative pulmonary evaluation?

• Physiologic changes in the respiratory system occur in all patients undergoing surgical/anesthetic procedures.

• These changes may lead to complications, mortality and/or morbidity.
Postoperative Complications
(Within 30 days of surgery)

• Acute CO$_2$ retention (PaCO$_2$ > 45 mm Hg)
• Prolonged mechanical ventilation (> 48 h)
• Infections (bronchitis & pneumonia)
• Atelectasis (necessitating bronchoscopy)
• Bronchospasm
• Exacerbation of the underlying chronic lung disease
• Pulmonary embolism
• Symptomatic cardiac arrhythmias
• Myocardial infarction
• Death


Preoperative Evaluation

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.

Objectives of Preoperative Pulmonary Evaluation

• RISK ASSESSMENT – *to identify* patients who are at increased risk of respiratory morbidity and mortality

• RISK REDUCTION – *to institute* corrective and preventive measures *to minimize* the risk of respiratory morbidity and mortality
Preoperative Evaluation for Lung Resection Surgery

Who should be evaluated?
The general answer....

All patients undergoing lung resection surgery, irrespective of age or extent of the lesion.

But unlike general surgery, preoperative evaluation of patients scheduled for lung resection, requires spirometry testing and, if necessary, cardiopulmonary exercise testing (CPET).
Current International Guidelines


British Thoracic Society (BTS) / Society for Cardiothoracic Surgery in Great Britain and Ireland - 2010

European Respiratory Society (ERS) / European Society of Thoracic Surgery (ESTS) - 2009
CASE

Z. B., 82-year-old male former 40 pack years smoker

CXR = RUL mass

FNAB = Squamous cell carcinoma
Chest CT scan:
- 6.5 x 4.2 x 4.5 cm pleural based mass with punctate calcification & irregular, spiculated margins in the apical & posterior segments of RUL
- No enlarged lymph nodes seen.
- No pleural effusion seen.
- Liver and both adrenal glands appear normal.

Other Metastatic Work-ups: Negative

Clinical Stage: T2bN0M0 (Stage IIA)

Cardiac Evaluation: Low risk

Management Plan: Lung resective surgery
### Case: Pulmonary Function Tests

<table>
<thead>
<tr>
<th>Spirometry</th>
<th>Ref</th>
<th>Pre Meas</th>
<th>Pre % Ref</th>
<th>Post Meas</th>
<th>Post % Ref</th>
<th>% Chg</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV1/FVC</td>
<td>68</td>
<td>58</td>
<td></td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>1.88</td>
<td>1.26</td>
<td>67</td>
<td>1.27</td>
<td>68</td>
<td>0</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>2.97</td>
<td>2.18</td>
<td>73</td>
<td>2.30</td>
<td>77</td>
<td>6</td>
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<table>
<thead>
<tr>
<th>Diffusion</th>
<th>Ref</th>
<th>Pre Meas</th>
<th>Pre % Ref</th>
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</thead>
<tbody>
<tr>
<td>DLCO</td>
<td>4.1</td>
<td>3.0</td>
<td>72</td>
</tr>
<tr>
<td>DL/VA</td>
<td>1.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VA Liters</td>
<td>2.56</td>
<td></td>
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</tbody>
</table>
Role of Pulmonary Function Testing

- **Aim:** To determine the risk for respiratory complications and mortality based on the patient’s preoperative lung function and estimated section lung function.

- **FEV\(_1\):** predictive of postoperative complications, including death

- **DLCO:** predictive of postoperative complications, including death, length of hospital stay and hospital costs
Question 1

What will be your next step in the preoperative assessment?

A. Clear patient for RU lobectomy

B. Calculate for the percent predicted FEV$_1$ and DLCO ✔

C. Order a lung perfusion scan

D. Order CPET
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>PPO FEV$_1%$</td>
<td>Percent predicted postoperative FEV$_1$</td>
</tr>
<tr>
<td>PPO DLCO$%$</td>
<td>Percent predicted postoperative diffusing capacity for carbon monoxide</td>
</tr>
<tr>
<td>PPO VO$_2$ max$%$</td>
<td>Percent predicted postoperative maximal or peak oxygen consumption</td>
</tr>
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</table>

The PPO designation is added to indicate that the estimated parameter refers to the late postoperative period (3-6 months after the surgical procedure).

FEV\textsubscript{1} and PPO FEV\textsubscript{1}

- FEV\textsubscript{1} and PPO FEV\textsubscript{1} associated with increased respiratory morbidity & mortality rates

- FEV\textsubscript{1} an independent predictor of respiratory morbidity (OR, 1.1 for every 10% decrease in FEV\textsubscript{1})
  \[ \text{FEV}_1 < 30\% \rightarrow 43\% \text{ morbidity rate} \]
  \[ \text{FEV}_1 > 60\% \rightarrow 12 \% \text{ morbidity rate} \]

- Licker et al. (Ann Thorac Surg. 2006) confirmed that the best cutoff value of FEV\textsubscript{1} for predicting respiratory complications was 60%.

ACCP Evidence-Based CPG (3\textsuperscript{rd} Edition) 2013
Preoperative FEV₁

• Data from > 2,000 patients in 3 large series in the 1970s:
  Mortality rate of < 5% if –
    - Preoperative FEV₁ > 2 L for a pneumonectomy
    - Preoperative FEV₁ > 1.5 L for a lobectomy

• FEV₁ > 80% predicted accepted indicates that the patient should be considered suitable to undergo pneumonectomy without further evaluation.

ACCP CPG (2nd Edition) 2007
BTS CPG 2001
Preoperative FEV₁

- If there is no evidence of either undue dyspnea on exertion or interstitial lung disease and:

  \[ \text{FEV}_1 > 80\% \text{ predicted or } > 2 \text{ L} \rightarrow \text{suitable for resection including pneumonectomy without further physiologic evaluation.} \]

  \[ \text{FEV}1 \text{ is } > 1.5 \text{ L} \rightarrow \text{suitable for a lobectomy without further physiologic evaluation.} \]

ACCP CPG (2nd Edition) 2007
Absolute Values vs Percent Predicted

- Absolute values (preoperative FEV$_1$ and PPO FEV$_1$) did not predict surgical outcome defined by 30-day mortality and post-operative respiratory failure.

- In contrast, all values (preoperative FEV$_1$ and DLCO, PPO FEV$_1$ and PPO DLCO) expressed as a percentage of the normal predicted value) correlated significantly with both complicated post-operative course and poor surgical outcome.

- Recommendation: Percentage predicted rather than absolute lung function values be used in assessing patients for lung cancer surgery → future guidelines should adopt percentage predicted rather than absolute values.

DLCO and PPO DLCO

• Reduced PPO DLCO strongly associated with the risk of post-resection pulmonary complications & mortality

• % PPO DLCO → higher correlation with postoperative deaths than the % PPO FEV$_1$

• % PPO DLCO < 60% was associated with a 25% mortality & 40% pulmonary morbidity (Ferguson et al) – confirmed by other authors

ACCP Evidence-Based CPG (3rd Edition) 2013
Correlation between FEV$_1$ and DLCO

- Correlation between FEV$_1$ and DLCO is consistently poor.
- Reduced PPO DLCO is a predictor of cardiopulmonary complications and mortality even in patients with an otherwise normal FEV$_1$.
- More than 40% of patients with an FEV$_1$ > 80% may have a DLCO < 80%; 7% of them may have a PPO DLCO < 40%.

ACCP CPG (3rd Edition) 2013
Recommendation: Lung Function

ALL patients for lung resection

Measure both FEV$_1$ and DLCO and Calculate both PPO FEV$_1$ and PPO DLCO
Recommendation: FEV₁ and DLCO

**ACCP (2013)**
Both PPO FEV₁ and PPO DLCO > 60% *

**ERS (2009)**
Both FEV₁ and DLCO 80%

No further tests recommended

**LOW RISK**

* PPO FEV₁ or PPO DLCO cut off values of 60% predicted values has been chosen based on indirect evidences and expert consensus opinion.
Estimation of PPO FEV$_1$ and PPO DLCO

Anatomic Method (Segment Counting): only for lobectomy

$\text{PPO FEV}_1 = \text{preoperative FEV}_1 \times (1 - \frac{y}{z})$

*the best measured postbronchodilator value*

$\text{PPO DLCO} = \text{preoperative DLCO} \times (1 - \frac{y}{z})$

$y = \text{the number of functional or unobstructed lung segments to be removed}$

$z = \text{the total number of functional segments}$

ACCP CPG (3rd Edition) 2013
PPO FEV₁ = preop FEV₁ x (1 – number of functional or unobstructed lung segments to be resected / total number of functional segments)

PPO DLCO = preop DLCO x (1 – number of functional or unobstructed lung segments to be resected / total number of functional segments)

* Only segments not totally obstructed should be taken into account: evaluated by image techniques and/or bronchoscopy
PPO FEV$_1$ and PPO DLCO expressed as a percentage of predicted to calculate % PPO FEV$_1$ and DLCO:

\[
% \text{ PPO FEV}_1 = \frac{\text{computed PPO FEV}_1}{\text{predicted normal FEV}_1} \times 100
\]

\[
% \text{ PPO DLCO} = \frac{\text{computed PPO DLCO}}{\text{predicted normal DLCO}} \times 100
\]
Number of Lung Segments

Right Lung
- Superior Lobe: 3
- Middle Lobe: 2
- Inferior Lobe: 5

Left Lung
- Superior Lobe: 5
- Inferior Lobe: 4

Total segments:
- Right Lung: 10
- Left Lung: 9
Case: \( \text{FEV}_1 \) and DLCO

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Pre Meas</th>
<th>Pre % Ref</th>
<th>Post Meas</th>
<th>Post % Ref</th>
<th>% Chg</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{FEV}_1 ) (L)</td>
<td>1.88</td>
<td>1.26</td>
<td>67</td>
<td>1.27</td>
<td>68</td>
<td>0</td>
</tr>
<tr>
<td>DLCO</td>
<td>4.1</td>
<td><strong>3.0</strong></td>
<td>72</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Case: Calculation of PPO FEV₁ %

Anatomic Method (for RU lobectomy):

\[
PPO \text{ FEV}_1 = \text{preoperative FEV}_1 \times (1 - \frac{y}{z})
\]
\[
= 1.27 \times (1 - \frac{3}{19})
\]
\[
= 1.27 \times (1 - 0.158)
\]
\[
= 1.27 \times 0.842
\]
\[
= 1.069 \approx 1.07 \text{ L}
\]

\[
PPO \text{ FEV}_1 \% = \left[\frac{\text{PPO FEV}_1}{\text{pred FEV}_1}\right] \times 100
\]
\[
= \left[\frac{1.07}{1.88}\right] \times 100
\]
\[
= 0.569 \times 100 = 56.9\% \approx 57\%}

Case: Calculation of PPO DLCO %

Anatomic Method (for RU lobectomy):

\[
PPO \text{ DLCO} = \text{preoperative DLCO} \times (1 - \frac{y}{z})
\]
\[
= 3.0 \times (1 - 3/19)
\]
\[
= 3.0 \times (1 - 0.158)
\]
\[
= 3.0 \times 0.842
\]
\[
= 2.526 \approx 2.53
\]

\[
PPO \text{ DLCO} \% = \left[\frac{PPO \text{ DLCO}}{\text{predicted DLCO}}\right] \times 100
\]
\[
= \left[\frac{2.53}{4.1}\right] \times 100
\]
\[
= 0.617 \times 100 = 61.7 \% \approx 62\%
\]
Case: PPO FEV$_1$ % and PPO DLCO %

Anatomic Method (for RU Lobectomy)

PPO FEV$_1$ % = 57 %
PPO DLCO % = 62 %
Question 2

Based on calculated PPO FEV$_1$ % and PPO DLCO% by anatomic method, what is your assessment?

A. Assess as low risk for RU lobectomy
B. Assess as moderate risk for RU lobectomy
C. Assess as high risk for RU lobectomy
D. Needs further assessment; Order a perfusion scan

☑️ D. Needs further assessment; Order a perfusion scan
Quantitative Radionuclide Scanning

- Anatomic (segment counting) method: recommended only to estimate lung function after a lobectomy

- To estimate the PPO FEV$_1$ and DLCO after pneumonectomy → A quantitative radionuclide perfusion scan is performed to measure the fraction of total perfusion for the resected lung.

- Either ventilation or perfusion scan can be used to predict PPO lung function. Perfusion scan more commonly used. No additional benefit in performing both.

Beckles et al, physiologic evaluation of patients with lung cancer being considered for resectional surgery. Chest 2003
Perfusion Method: to calculate predicted postoperative values of FEV$_1$ or DLCO for pneumonectomy

- PPO FEV$_1 = \text{preoperative FEV}_1 \times (1 - \text{fraction of total perfusion for the resected lung})$
  
  * the best measured postbronchodilator values

- PPO DLCO = preoperative DLCO $\times (1 - \text{fraction of total perfusion for the resected lung})$

PPO FEV$_1$ and PPO DLCO $\rightarrow$ expressed as a percentage of predicted to calculate $\%$ PPO FEV$_1$ and DLCO
## Case: Lung Perfusion Scan

<table>
<thead>
<tr>
<th>Zone</th>
<th>Right Lung</th>
<th>Left Lung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Zone</td>
<td>9.1 %</td>
<td>13.5 %</td>
</tr>
<tr>
<td>Middle Zone</td>
<td>25.3 %</td>
<td>29.2 %</td>
</tr>
<tr>
<td>Lower Zone</td>
<td>12.6 %</td>
<td>10.3 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>47 %</strong></td>
<td><strong>53 %</strong></td>
</tr>
</tbody>
</table>
Case : Calculation of PPO FEV$_1$

Perfusion Method (for RU lobectomy):

\[
PPO \text{ FEV}_1 = \text{preoperative FEV}_1 \times (1 - \text{fraction of total perfusion for the resected lung})
\]

\[
= 1.27 \times (1 - 9.1 \%) \\
= 1.27 \times (1 - 0.091) \\
= 1.27 \times 0.909 \\
= 1.15443 \approx 1.15 \text{ L}
\]

\[
PPO \text{ FEV}_1 \% = \left[ \frac{\text{PPO FEV}_1}{\text{pred FEV}_1} \right] \times 100
\]

\[
= \left[ \frac{1.15}{1.88} \right] \times 100
\]

\[
= 0.612 \times 100 = 61.2 \%
\]
Case: Calculation of PPO DLCO

Perfusion Method (for RU lobectomy):

\[
PPO \text{ DLCO} = \text{preoperative DLCO} \times (1 - \text{fraction of total perfusion for the resected lung})
\]

\[
= 3.0 \times (1 - 9.1\%)
\]

\[
= 3.0 \times (1 - 0.091)
\]

\[
= 3.0 \times 0.909
\]

\[
= 2.727 \approx 2.73
\]

\[
PPO \text{ DLCO}\% = \left[ \frac{\text{PPO DLCO}}{\text{pred DLCO}} \right] \times 100
\]

\[
= \left[ \frac{2.73}{4.1} \right] \times 100
\]

\[
= 0.666 \times 100 = 66.6\%
\]
Case : Calculation of PPO FEV₁

Perfusion Method (for Right Pneumonectomy):

PPO FEV₁ = preoperative FEV₁ x (1 - fraction of total perfusion for the resected lung)

= 1.27 x (1 - 47 %)
= 1.27 x (1 - 0.47)
= 1.27 x (0.53)
= 0.67

PPO FEV₁ % = [PPO FEV₁ / pred FEV₁] x 100
= [0.67 / 1.88] x 100
= 0.356 x 100 = 35.6 %
Case: Calculation of PPO DLCO

Perfusion Method (for Right Pneumonectomy):

\[ \text{PPO DLCO} = \text{preoperative DLCO} \times (1 - \text{fraction of total perfusion for the resected lung}) \]

\[ = 3.0 \times (1 - 47\%) \]

\[ = 3.0 \times (1 - 0.47) \]

\[ = 3.0 \times 0.53 \]

\[ = 1.59 \]

\[ \text{PPO DLCO} \% = \left[ \frac{\text{PPO DLCO}}{\text{pred DLCO}} \right] \times 100 \]

\[ = \left[ \frac{1.59}{4.1} \right] \times 100 \]

\[ = 0.388 \times 100 = 38.8\% \]
Case: Summary of PPO FEV$_1$% and PPO DLCO%

Anatomic Method: RU Lobectomy
- PPO FEV$_1$ % = 57 %
- PPO DLCO % = 62 %

Perfusion Method: RU Lobectomy
- PPO FEV$_1$ % = 61.2 %
- PPO DLCO % = 66.6 %

Perfusion Method: R Pneumonectomy
- PPO FEV$_1$ % = 35.6 %
- PPO DLCO % = 38.8 %
Question 3

At this point, what is your risk assessment of this patient?

A. Low risk for both RU lobectomy and R pneumonectomy
B. Moderate risk for both RU lobectomy and R pneumonectomy
C. High risk for both RU lobectomy and R pneumonectomy
D. Low risk for RU lobectomy, but needs further test for possible R pneumonectomy

✓
The objective is to ascertain that after surgical resection of the lung, 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 a pneumonectomy, even if it is believed preoperatively that all that is needed is a lobectomy or a wedge resection.

If during the exploratory thoracotomy the tumor crosses the major fissure or extends to the hilum and a pneumonectomy is needed, the opportunity for an extensive physiologic evaluation is generally too late.

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Question 4

What additional test will you order to further assess risk for pneumonectomy?

A. 6 minute walk test
B. Stair climb
C. Shuttle walk test
D. CPET
E. Any of the above
Exercise Tests

• Aim of exercise testing: to stress the whole cardio-pulmonary / systemic oxygen delivery systems and estimate the physiological reserve that may be available after surgery.

• Meta-analysis by Benzo et al. (Respir Med 2007): has shown that exercise capacity, expressed as VO$_2$ peak is lower in patients that develop post-operative cardiorespiratory complications after lung resection. (Bolliger et al. Eur Respir J 1996)

• Besides early postoperative outcome, performance on exercise tests is also a better predictor of long-term exercise capacity than conventional pre-operative PFTs.

• Nevertheless, exercise tests are usually recommended only in selected cases (unfit or reduced FEV1 and/or DL,CO)

Cardiopulmonary Exercise testing (CPET)

- CPET: a sophisticated physiologic testing technique that provides an objective evaluation of functional capacity of both the lungs & heart and is known as a safe test procedure
- Inability to perform a preoperative exercise test → indication of limited aerobic capacity
- Recommended by previous & current guidelines as the next step in the preoperative risk-assessment process in those patients with compromised pulmonary function.

ACCP Evidence-Based CPG 2013
Tilburg et al. Eur Respir J 2009; 33
Cardiopulmonary Exercise Testing

• Standardized CPET using VO$_2$ max has been shown to predict postoperative complications, including perioperative and long-term morbidity and mortality

• ACCP: CPET indicated
  - positive high-risk cardiac evaluation
  - either FEV$_1$ or DLCO < 30% or
  - SCT < 22 m or SWT < 400 m

• ERS: CPET recommended when FEV$_1$ or DLCO < 80%
Cardiopulmonary Exercise Testing

The risk for perioperative complications has been reported to be higher with lower measured VO$_2$ max:

• **VO$_2$ max > 20 ml/kg/min or > 75% predicted:**
  - can safely undergo the planned resection (up to pneumonectomy)

• **VO$_2$ max between 10-15 ml/kg/min or between 35%-75% predicted:**
  - indicates an increased risk of perioperative death compared with higher values of VO$_2$ max.

• **VO$_2$ max of <10 ml/kg/min or < 35% predicted:**
  - very high risk for postoperative death
  - generally regarded as a contraindication to major anatomic resections

ACCP Evidence-Based CPG (3rd Edition) 2013
Low Technology Exercise Tests

STAIR CLIMBING TEST (SCT)

• Can be used as a first-line functional screening test to select those patients that can undergo safely to operation (height of ascent > 22 m)

• Limitation of test: lack of standardization - the duration of stair climbing, the speed of ascent, the number of steps per flight, the height of each step, and the criteria for stopping the test have varied from study to study.
Low Technology Exercise Tests

SHUTTLE WALK TEST (SWT)

• Procedure:
  - Requires the patient to walk back and forth between 2 markers set 10 m apart
  - Walking speed is increased each minute in a graded fashion and paced by an audio signal
  - End of test: when patient is too breathless to maintain speed

• Inability to complete 25 shuttles (250 m) on 2 occasions suggests a VO$_2$ max of < 10 ml/kg/min

M. Beckles et al. CHEST 2003;123
ACCP CPG (2nd Edition) 2007
Low Technology Exercise Tests

SIX MINUTE WALK TEST (SMWT)

• Procedure measures the distance that the patient can quickly walk on a flat, hard surface in a period of 6 minutes.

• Patients instructed to walk as far as possible in a period of 6 minutes. Rest during the test is permissible.

• Interpretation of the distance walked in 6 min currently not well standardized.

• Current guidelines: The 6-min walk test should not be used to select patients for operation.

ERS/ESTS CPG 2009
Recommendation: Exercise Tests

High-risk Cardiac evaluation

PPO FEV₁ or PPO DLCO < 30%

PPO FEV₁ and/or PPO DLCO Between 30%-60%

CPET

SCT < 22 m or SWT < 400m

Stair Climb or Shuttle Walk Test
Recommendation: CPET

VO₂ max
> 20mL/kg/min or > 75%

VO₂ max
10-20mL/kg/min or 35% - 75%

VO₂ max
< 10mL/kg/min or < 35%

LOW RISK

MODERATE RISK

HIGH RISK

ACCP CPG (3rd Edition) 2013
ERS/ESTS CPG 2009
Estimation of PPO VO$_2$ max

For Pneumonectomy:

$$\text{PPO VO}_2 \max = \text{preoperative VO}_2 \max \times (1 - \text{fraction of total perfusion for the lung to be resected})$$

ERS/ESTS CPG 2009
Physiologic Evaluation Resection Algorithm

Algorithm for Thoracotomy and Major Anatomic Resection (Lobectomy or greater)

Positive high-risk cardiac evaluation

VO2max <10 ml/kg/min Or < 35%

High Risk

VO2max 10-20 ml/kg/min Or 35%-75%

Moderate Risk

VO2max >20 ml/kg/min Or >75%

Low Risk

ppoFEV1 or ppoDLCO <30%

ppoFEV1 or ppoDLCO <60% AND both >30%

ppoFEV1 and ppoDLCO > 60%

Stair climb or Shuttle walk

SCT <22m OR SWT < 400m

>22m OR >400m

ACCP Evidence-Based Clinical Practice Guidelines (2013)
• Indicates that the patient’s functional reserve is sufficient to withstand the stress of surgery and perform daily activities in the late postoperative period.

• The expected risk of mortality is below 1%.

• Major anatomic resections can be safely performed in this group.

ACCP CPG (3rd Edition) 2013
Degani-Costa, et al.
Rev Bras Anestesiol. 2014
Morbidity and mortality rates may vary according to the values of split lung functions, exercise tolerance and extent of resection.

The benefit of surgery is considered to outweigh the risks.

Risks and benefits of the operation should be thoroughly discussed with the patient.
• Generally considered a contraindication to surgery due to the high mortality rate (>10%) after standard major anatomic resections.

• Considerable risk of severe cardiopulmonary morbidity and residual functional loss is expected.

• Patients should be counseled about alternative surgical (minor resections or minimally invasive surgery) or nonsurgical options.
Proposed Algorithm for Preoperative Risk Assessment for Lung Resection

1. FEV₁ DLCO
   - FEV₁ and DLCO both > 80%?
     - YES → LOW RISK
     - NO → PPO FEV₁ % and PPO DLCO %
2. PPO FEV₁ % and PPO DLCO %
   - PPO FEV₁ and PPO DLCO both > 60%?
     - YES → LOW RISK
     - NO → CPET
3. CPET
   - VO₂ max > 20 ml/kg/min or > 75%
     - LOW RISK
   - VO₂ max 10-20 ml/kg/min or 35% - 75%
     - MODERATE RISK
   - VO₂ max < 10 ml/kg/min or < 35%
     - HIGH RISK
All patients being considered for lung resection should undergo preoperative physiologic evaluation.

Pulmonary function testing using spirometry (FEV₁), DLCO and VO₂ max help predict the risk of post-operative complications and mortality.

Predicting postoperative lung function using the proportion of lung segments to be resected, perfusion scanning, or other methods is important for assessing surgical risk.

Current international guidelines provide algorithms for preoperative risk assessment.