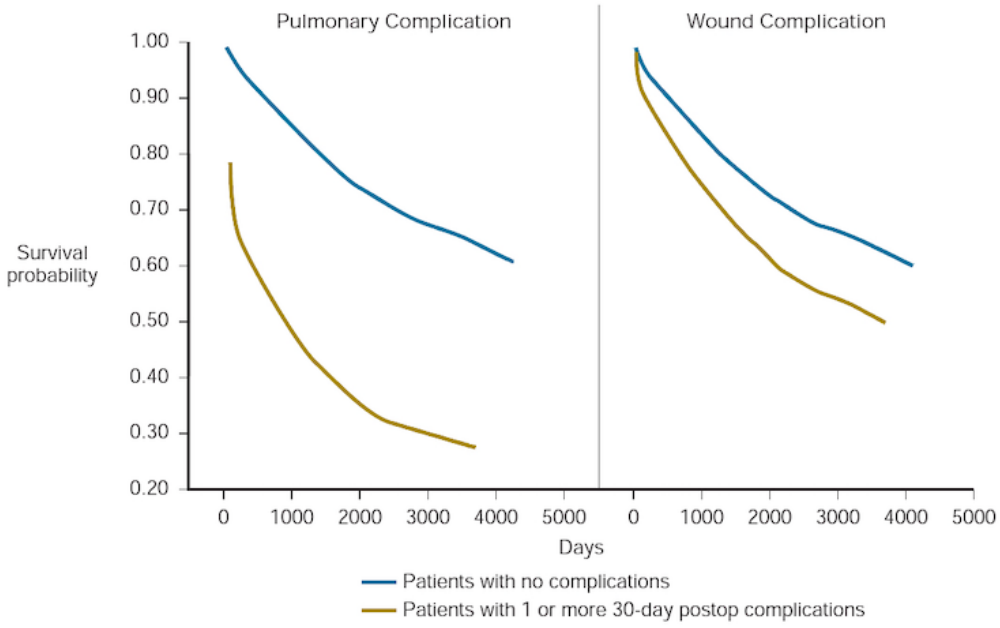
Preoperative Pulmonary Evaluation

Case related questions

Scenario:

Patients with perioperative pulmonary complications (PPCs) have high rates of mortality (short- and long-term mortality (Figure 1)) and morbidity. They also have more ICU admissions, longer, hospital length of stay, and associated cost of care. Rates of complications differ for thoracic and non- thoracic surgeries, patient populations and based on the definition definitions of "complications." Current literature varies widely in criteria to label a PPC, so incidence ranges are wide. A common definition of PPC used in several articles is the following: *any pulmonary abnormality occurring in the postoperative period that produces identifiable disease or dysfunction which is clinically significant and adversely affects the clinical course*. Risk stratifying patients can help anticipate complications based on their risk and optimize them when possible.

Figure 1. Post Operative Complications and Mortality Risk



Postoperative pulmonary complications (PPCs) have a significant influence on long-term mortality. Cox survival curves of study patients stratified as to whether or not the patients had sustained a PPC (*left*) or wound complication (*right*) in the first 30 postoperative days. Compared to wound complications, pulmonary complications had a disproportionate impact on survival. (From Khuri SF, Henderson WG, DePalma RG, et al: Determinants of long-term survival after major surgery and the adverse effect of postoperative complications. *Ann Surg* 242[3]:326–341; discussion 341–343, 2005.)

Figure borrowed from Broaddus CV, Mason RJ, King Jr TE et al. *Murray and Nadel's Textbook of Respiratory Medicine* 6th ed. Elsevier, 2016.

Scenario, cont.:
Ms. R. is a 35-year-old woman referred for evaluation of preoperative pulmonary risk before an elective open cholecystectomy that is tentatively scheduled to happen in two weeks. She has cholelithiasis and has had 2 prior episodes of acute cholecystitis. Because of a previous abdominal gunshot wound and subsequent adhesions, she was advised to undergo open rather than laparoscopic cholecystectomy.

Past medical history is notable for moderate persistent asthma. She has approximately 3 exacerbations per year, requiring a course of oral corticosteroids. She was hospitalized one year ago with a severe exacerbation but did not require intubation. Her last exacerbation requiring a course of outpatient oral steroids was two weeks ago. She is currently on high-dose inhaled corticosteroids, a long-acting beta-agonist, and a rescue short-acting beta agonist as needed. Currently, she needs to use her rescue inhaler 2-3 times per week. She is a non-smoker.

On examination, she is obese, with a BMI of 35. Vital signs are normal; O_2 saturation by pulse oximetry is 91% on ambient air. On chest examination, there are some scattered expiratory wheezes in both lungs. A cardiac examination is unremarkable. Abdominal examination is notable for mild right upper quadrant tenderness. The liver is not enlarged, and the gallbladder is not palpable.

Question 1: What are the potential risk factors of concern for Ms. R?

Question 2: What testing should be done before surgery that does not involve lung resection or cardiothoracic surgery?

Question 3: Are there scoring systems to predict postoperative risk?

Question 4: What pre-operative strategies can be considered in patients undergoing non-thoracic surgery?

Scenario, cont.:
Mr. C. is a 67-year-old man with longstanding COPD and recently diagnosed non-small cell lung cancer that presented as a 4 cm RUL mass. CT-PET scan was negative for mediastinal lymph node involvement. He has a 90-pack year smoking history. He tried unsuccessfully on multiple occasions to stop smoking, and he is currently smoking ½ pack per day.

On examination, he is thin, and he breathes with pursed lips during expiration. Vital signs are normal except for an O_2 saturation of 90% on ambient air. There is no cervical or supraclavicular adenopathy. Chest examination shows diffusely decreased breath sounds with mild expiratory wheezing. Cardiac examination is notable for distant heart sounds but no murmur or gallop. He has scattered centrilobular emphysema. There is no clubbing or peripheral edema.

Mr. C. has a thoracic surgery consultation, and the recommendation is for him to undergo thoracotomy with probable lobectomy. However, given the position of the tumor, it is possible he may need to have a pneumonectomy.

Question 5: What functional studies should be done as part of the preoperative evaluation to assess whether he has sufficient reserve to undergo lobectomy (and possibly pneumonectomy)?

Question 6: When is there value in predicting postoperative pulmonary function, and how is it done?

Question 7: When does further testing need to be done?

Question 8: How are the stair-climb and the incremental shuttle walk tests performed?

Question 9: What is the role of formal cardiopulmonary exercise testing (CPET)?

Preoperative Pulmonary Evaluation

Author Steven Weinberger, MD,
Kavitha Bagavathy, MBBS

Editor Susan K. Mathai, MD

Literature review current through June 2025
Last updated June 2025

Section Editors

2025 Hetal Patel, MD
2023 May M. Lee, MD, MHA
Brannen Liang, MD
Susan K. Mathai, MD
2021 Meredith E. Pugh, MD
Rosemarie Dudenhofer, MD
Abhaya Trivedi, MD

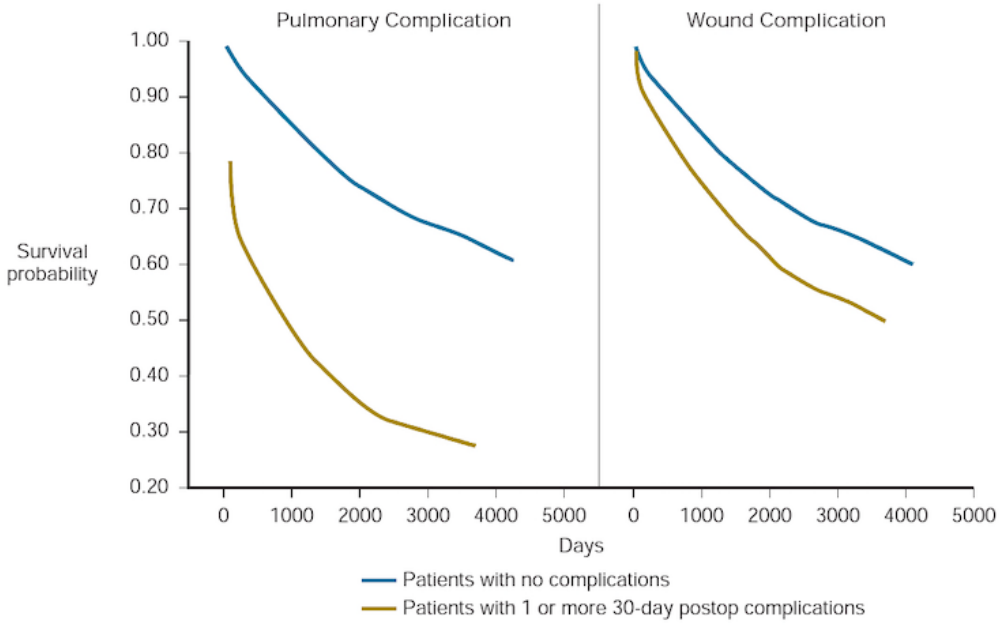
Citation
Weinberger S. Bagavathy K. on the Preoperative Pulmonary Evaluation. In: Patel H, et al eds. Association of Pulmonary and Critical Care Program Directors Ambulatory Care Teaching Scripts. 2025. https://apccmpdscholars.org/tool/ambulatory-care-curriculum/.

Educational Objectives:

1. Define perioperative pulmonary risk
2. Review the risk factors associated with respiratory complications from nonthoracic and thoracic surgery
3. Understand the evaluation of patients undergoing non-thoracic surgery
4. Review the objective determination of risk for patients with lung disease undergoing pulmonary resection

Scenario:
Patients with perioperative pulmonary complications (PPCs) have high rates of mortality (short- and long-term mortality (Figure 1)) and morbidity. They also have more ICU admissions, longer, hospital length of stay, and associated cost of care. Rates of complications differ for thoracic and non- thoracic surgeries, patient populations and based on the definition definitions of "complications." Current literature varies widely in criteria to label a PPC, so incidence ranges are wide. A common definition of PPC used in several articles is the following: *any pulmonary abnormality occurring in the postoperative period that produces identifiable disease or dysfunction which is clinically significant and adversely affects the clinical course*. Risk stratifying patients can help anticipate complications based on their risk and optimize them when possible.

Figure 1. Post Operative Complications and Mortality Risk



Postoperative pulmonary complications (PPCs) have a significant influence on long-term mortality. Cox survival curves of study patients stratified as to whether or not the patients had sustained a PPC (*left*) or wound complication (*right*) in the first 30 postoperative days. Compared to wound complications, pulmonary complications had a disproportionate impact on survival. (From Khuri SF, Henderson WG, DePalma RG, et al: Determinants of long-term survival after major surgery and the adverse effect of postoperative complications. *Ann Surg* 242[3]:326–341; discussion 341–343, 2005.)

Figure borrowed from Broaddus CV, Mason RJ, King Jr TE et al. *Murray and Nadel's Textbook of Respiratory Medicine* 6th ed. Elsevier, 2016.

Common PPCs (including thoracic and extra-thoracic procedures):

- Respiratory infections: pneumonia or bronchitis
- Lobar or whole lung atelectasis
- Respiratory failure: hypoxemia or hypercapnia (Mechanical ventilation >48 hours after surgery, unplanned reintubation, use of non-invasive ventilation, use of increased F_iO_2)
- Pulmonary embolism
- Pleural effusion and pulmonary edema
- Acute Respiratory Distress syndrome (ARDS)
- Bronchospasm
- Aspiration pneumonitis
- Pneumothorax
- Hemodynamic instability in patients with Pulmonary vascular disease
- Exacerbation of underlying lung disease
- Persistent air leak > 7 days (thoracic surgery)

Scenario cont.:
Ms. R. is a 35-year-old woman referred for evaluation of preoperative pulmonary risk before an elective open cholecystectomy that is tentatively scheduled to happen in two weeks. She has cholelithiasis and has had 2 prior episodes of acute cholecystitis. Because of a previous abdominal gunshot wound and subsequent adhesions, she was advised to undergo open rather than laparoscopic cholecystectomy.

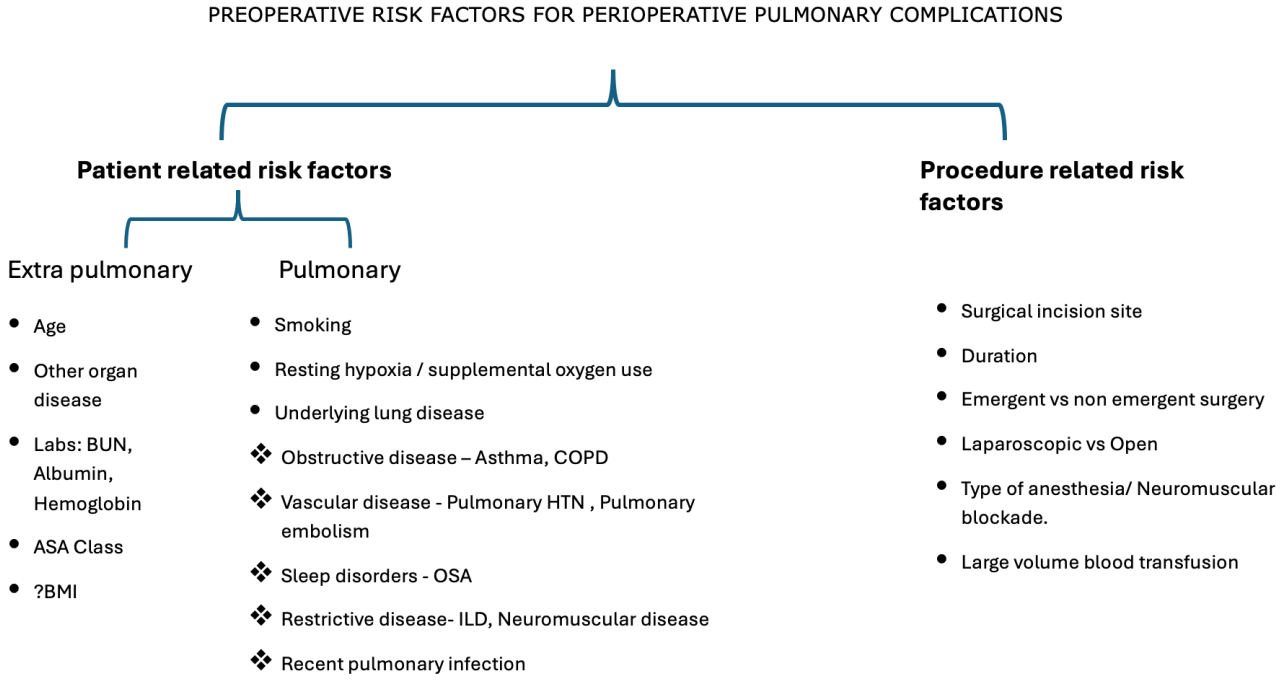
Past medical history is notable for moderate persistent asthma. She has approximately 3 exacerbations per year, requiring a course of oral corticosteroids. She was hospitalized one year ago with a severe exacerbation but did not require intubation. Her last exacerbation requiring a course of outpatient oral steroids was two weeks ago. She is currently on high-dose inhaled corticosteroids, a long-acting beta-agonist, and a rescue short-acting beta agonist as needed. Currently, she needs to use her rescue inhaler 2-3 times per week. She is a non-smoker.

On examination, she is obese, with a BMI of 35. Vital signs are normal; O_2 saturation by pulse oximetry is 91% on ambient air. On chest examination, there are some scattered expiratory wheezes in both lungs. A cardiac examination is unremarkable. Abdominal examination is notable for mild right upper quadrant tenderness. The liver is not enlarged, and the gallbladder is not palpable.

Question 1: What are the potential risk factors of concern for Ms. R?

Here is a proposed framework for the risk factors that need to be considered while evaluating a patient for risk of post operative pulmonary complications (Figure 2).

Figure 2. Preoperative Risk Factors for PPCs



Courtesy of the authors.

Patient related risk factors

A. Extrapulmonary

1. Age

>50 years is associated with higher risk Odds ratio (OR) of 1.5 Confidence Interval (CI) 1.31-1.71, and the relative risk increases with each decade above 50. Age greater than 80 years was associated with 5.6 times increased risk of PCCs.[1]

2. Other Organ Disease

Heart failure: associated with increased risk, OR 2.93 (CI 1.02 to 8.43).[2] It also has been shown to be a significant risk factor for postoperative respiratory failure and reintubation OR 2.36 [1.58-5.92]; p= 0.005.[1]

3. Labs

A multifactorial risk index for postoperative respiratory failure identified albumin less than 3 g/dL and blood urea nitrogen (BUN) greater than 30 mg/dL each predicted risk for post operative respiratory failure; odds ratios were 2.53 and 2.29, respectively.[3] Hemoglobin < 10 g/dl was identified as an independent risk factor in one large prospective multi-center study.[4]

4. American Society of Anesthesiologists Classification (ASA Class)

ASA class of ≥ 2 and ≥ 3 were respectively associated with a 4.87 [CI, 3.34 to 7.10] and 2.55 [CI, 1.73 to 3.76] fold increase in risk.[2]

5. BMI

Obesity has not been consistently shown to increase the risk of postoperative pulmonary complications except in patients undergoing emergency abdominal surgery.[5] Delaying elective surgery until patients have achieved weight loss may reduce risk of PPC. However, both high and low BMI can be problematic; lower BMI in patients with COPD was associated with a poorer prognosis, independent of disease severity.[1] In setting of lung cancer and lung resection, it might have a *protective* effect (marker of better nutritional status and immune status).[6]

B. Pulmonary

1. Smoking

i. What is the impact of smoking?

Smoking decreases macrophage function, impairs vascular endothelial function, decreases coronary reserve, increases risk of tachycardia, hypertension (HTN) and ischemia.

The effect of current tobacco use on PPC risk was dependent on type of surgery.[7] There is an increased risk of arterial desaturation and laryngospasm during anesthesia, increased CO levels and hence impaired oxygen carrying capacity. Smoking also increases thrombotic risk. One study shows that smokers have approx. 20-30% higher adjusted odds of post op mortality and major complications.[8] Smokers with ≥20 pack year smoking history have small airways disease even if spirometry is normal.

ii. When to stop smoking?

Some studies suggest increase in PPCs in patients who quit smoking less than 8 weeks before surgery. A minimum of a 4-weeks smoke free (ideally 8 weeks) is recommended before elective surgery.

However, it does seem that benefits increase with duration of smoking cessation- one meta-analysis of 6 RCTs and 15 observational studies demonstrated a relative risk reduction of 41% in PPCs with the magnitude of effect increased by 19% for each week of cessation.[9] Preoperative smoking cessation for year or greater is associated with reduced in-hospital morbidity and mortality.[10] There is debate about whether the risk of postoperative complications is increased if the patient stops smoking less than 4-8 weeks before the surgery. Physicians' advice to quit has been associated with higher abstinence rates.

2. Underlying lung disease

i. Asthma

Asthma that is well controlled at the time of surgery is unlikely to be a risk factor. Poorly controlled asthma/ active wheezing can increase risk of PPC. If persistent despite ICS / LABA, a short course of low dose systemic steroids can be considered without an impact on post operative wound healing.[11]

ii. Chronic Obstructive Pulmonary Disease (COPD)

COPD is associated with a 2-6 fold increase in risk of postoperative pulmonary complications.[2] Higher risk of post-op pneumonia, prolonged / difficulty weaning from mechanical ventilation and reintubation, MI, sepsis, cardiac arrest, renal insufficiency, wound dehiscence have been reported. Abnormal chest exam increases risk. Between 50-60% of patients with lung CA have COPD (independent of intensity of smoking). Pre-op optimization is similar to patients not evaluated for surgery. Pre-op pulmonary rehab is helpful, especially in those undergoing lung resection.

iii. Pulmonary Hypertension

Pulmonary Hypertension is associated with increased mortality and morbidity irrespective of underlying etiology. NYHA class >=2, anesthesia > 3 hrs., intermediate / high risk surgery (*based on ACC/AHA summary reported risk of cardiac death or non-fatal MI)* are risk factors. There is increased risk of hypoxemia and circulatory collapse. The preoperative evaluation must be carefully planned among PH specialists, anesthesiology, and surgical teams.[12]

iv. Obstructive Sleep Apnea (OSA)

OSA adds 2-4 fold increased risk. The risk is higher if associated with hypoventilation and daytime hypercarbia. In one study involving patients undergoing hip or knee replacements the incidence of PPC / cardiac complications in OSA vs non OSA was 39% vs 18% and ICU admissions

were 24% vs 9%.[13] Complications include hypoxemia, pneumonia, difficult intubation, MI, PE, atelectasis and arrhythmias. If there is a clinical suspicion for OSA, check the STOP BANG (STOP: Snoring, Tiredness during daytime, observed apnea, high blood Pressure BANG: (BMI, Age, Neck circumference, Gender) score, if ≥5, consider testing and initiating treatment.

v. Restrictive lung disease

a. Interstitial lung disease
Robust data is unavailable, but increased risk has been reported with DLCO< 60% pred, pre-operative oxygen use, presence of pulmonary hypertension**,** low BMI (< 23 kg/m^2) and/or those undergoing emergency surgery or lung cancer resection.[14]

b. Neuromuscular disease (includes Rib cage abnormalities like scoliosis and neuromuscular weakness)
No robust data regarding increased risk of PPC**.** Preoperative inspiratory muscle training might be of benefit.

c. Upper respiratory tract infections
No clear data for association with increased risk but may be wise to defer elective surgery until treatment is complete. Recommend treating exacerbation of lung disease due to infection prior to elective surgery if possible.

Procedure related risk factors

A. Site of surgery
Upper abdominal (including abdominal aortic aneurysm) and thoracic surgical procedures have the highest risk for postoperative pulmonary complications (Brooks-Brun, Chest 1997). Inspiratory pain, splinting, and diaphragm dysfunction are of particular concern with upper abdominal surgery, leading to decreased FRC and tidal volume (with subsequent atelectasis and hypoxemia) and impaired cough (with subsequent infection). These problems may also be complicated by the respiratory depressant effect of opioids for postoperative pain. Vital capacity may be reduced 50-60% postoperatively in these patients, and the reduction may persist for days. Other types of surgery pose less of a problem: lower abdominal surgery is associated with less reduction in VC, and extremity surgery is not associated with changes in pulmonary function. Incidence of complications varies across the literature based on definition, but range from 19-59% for thoracic surgeries, 16-17% for upper abdominal and 0-5% for lower abdominal surgeries.[15]

B. Duration of surgery

Longer duration (typically > 2 hours) is associated with higher risk than shorter surgery.

C. Anesthetic type

General anesthesia is associated with higher risk than spinal/epidural anesthesia. The decision of anesthetic approach is usually driven by other factors.

D. Inherent surgical risk

Emergent surgeries are associated with higher risk when compared to elective surgeries. Operative volume of the hospital where surgeries like lung resection are performed has important impact on outcomes.[16]

E. Large Volume transfusions

Surgeries involving large volume transfusions > 4 units of PRBC have a higher risk of developing complications (Transfusion related acute lung injury (TRALI) vs Transfusion associated cardiac overload (TACO).)

F. Laparoscopic vs open

The laparoscopic approach decreases risk of postoperative complications relative to open cholecystectomy.[17]

To summarize, Ms. R's risk factors include the plan for open surgery, the recent asthma exacerbation less than a month ago, poor symptom control despite current inhaler regimen, low O2 saturation on room air and wheezing on exam. Her BMI should prompt screening for OSA.

Question 2: What testing should be done before surgery that does not involve lung resection or cardiothoracic surgery?

A. Spirometry

Data are conflicting about whether preoperative spirometry predicts risk for postoperative pulmonary complications. It does not appear to be as important as the site and the length of surgery. The American College of Physicians guideline from 2006 recommends that preoperative spirometry not be routinely performed. Spirometry is reasonable in patients with COPD or asthma to assess whether they are at baseline and whether they need more intensive treatment prior to surgery. There is no absolute spirometric cutoff indicating that surgery is contraindicated. There is also no expert consensus on using spirometry to risk stratify restrictive lung or neuromuscular disease, as no studies exist for this patient population.[2]

1. Arterial blood gas

Routine testing is not indicated. Small case series have shown a higher risk on patients with $PaCO_2$ > 45 mm Hg in severe COPD patients. The resting room air saturation has been noted to be an independent risk factor in one study.[4]

B. Chest imaging

Routine preoperative CXRs in absence of known or suggested cardiothoracic disease are NOT indicated .CXR can help in patients with known cardiopulmonary disease if not at baseline , unexplained respiratory symptoms. The ASA recommends Chest X rays in those age >50 for high risk procedures.

C. Exercise testing

Not routinely recommended for Non-Thoracic procedures.

D. Sleep study

In patients with STOP BANG score ≥5 and planned for elective surgery, a sleep study to diagnose and treat OSA can reduce incidence of PPCs.

Enhanced STOP-BANG stratifies the following patients as high suspicion for sleep apnea[18] :

Yes to any one of the BANG questions

- Yes 2/4 STOP questions + Male gender
- Yes 2/4 STOP questions + BMI>35 kg/m^2
- Yes 2/4 STOP questions + neck circumference >40 cm (16 in)

Question 3: Are there scoring systems to predict postoperative risk?

Examples of scores include:

Table 1. ARISCAT Risk Index

Factor	Parameters	Points
Age	≤50yrs old	0
	51-80 yrs old	3
	>80 yrs old	16
Pre-operative oxygen saturation	≥96%	0
	91-95%	8
	≤90%	24
Other clinical risk factors	Respiratory infection in the last month	17
	Preoperative anemia with Hgb ≤10 g/dL	11
	Emergency surgery	8
Surgical Incision	Upper abdominal	15
	Intrathoracic	24
Duration of Surgery	≤2 hrs	0
	2-3 hrs	16
	>3 hrs	23

0-25 points: LOW risk; 1.6% pulmonary complication rate
26-44 points: INTERMEDIATE risk; 13.3% pulmonary complication rate
45-123 points: HIGH risk; 42.1% pulmonary complication rate
From Canet, et al, Anesthesiology 2010.

ARISCAT was found to be superior to ASA at predicting pulmonary postoperative risk.

Note how many of the risk factors are non-modifiable such as the age and the inherent surgical risk, which need to be taken into account while stratifying risk. All emergent surgeries, surgeries that involve intrathoracic interventions (Aortic / major vascular surgeries, thoracic resection surgeries) and duration lasting greater than 3 hours (in addition to most emergent and intrathoracic surgeries, peripheral vascular surgeries, certain orthopedic procedures, head and neck surgeries and prostate surgery) automatically place patients at moderate to high risk of complications.

Additional scoring systems to calculate postoperative risk:

1. Arozullah respiratory failure index[3] (note women were excluded)
2. Gupta calculators for postoperative respiratory failure or postoperative pneumonia

Question 4: What pre-operative strategies can be considered in patients undergoing non-thoracic surgery?

Preoperative strategies for optimization can include (on a case-by-case basis)

1. Smoking cessation counseling
2. COPD optimization – maintenance therapies, consider delaying surgery if acute exacerbation
3. Asthma control if not adequate
4. Pulmonary rehab / lung expansion maneuvers / Inspiratory muscle training (initiate per-op as patients are more receptive to learning these before surgery)
5. Pre- treatment with bronchodilators / steroids if needed

Scenario cont.:
Mr. C. is a 67-year-old man with longstanding COPD and recently diagnosed non-small cell lung cancer that presented as a 4 cm RUL mass. CT-PET scan was negative for mediastinal lymph node involvement. He has a 90-pack year smoking history. He tried unsuccessfully on multiple occasions to stop smoking, and he is currently smoking ½ pack per day.

On examination, he is thin, and he breathes with pursed lips during expiration. Vital signs are normal except for an O_2 saturation of 90% on ambient air. There is no cervical or supraclavicular adenopathy. Chest examination shows diffusely decreased breath sounds with mild expiratory wheezing. Cardiac examination is notable for distant heart sounds but no murmur or gallop. He has scattered centrilobular emphysema. There is no clubbing or peripheral edema.

Mr. C. has a thoracic surgery consultation, and the recommendation is for him to undergo thoracotomy with probable lobectomy. However, given the position of the tumor, it is possible he may need to have a pneumonectomy.

Question 5: What functional studies should be done as part of the preoperative evaluation to assess whether he has sufficient reserve to undergo lobectomy (and possibly pneumonectomy)?

Lobectomies and pneumonectomies inherently are moderate to high-risk procedures by virtue of the incision site, duration and age of most patients (since most are performed for lung cancer). Most patients have their cardiac risk assessed first based on the Thoracic

revised cardiac index [ThRCRI]. If their ThRCRI score is less than 2, with good exercise tolerance and have no active or suspected cardiac conditions, a PFT is the next step.[19] The most important studies predictive of operative risk and surgical outcome are FEV1 and DLCO. Therefore, Mr. C should have preoperative spirometry and measurement of DLCO.

> FEV1: A preoperative FEV_1 <60% is the strongest predictor of postoperative complications including mortality.
>
> DLCO: A preoperative DLCO <60% predicted is an independent and very strong predictor of post operative complications including death and length of hospital stay.

ACCP guidelines do not specify an absolute threshold for preoperative FEV_1 or DLCO below which surgery should not be performed.[21] However, together, a pre- OP FEV1 AND a pre-op DLCO ≥ 80% predicted stratifies a patient as low risk for proceeding with a lobectomy or pneumonectomy. Definitions of "risk" for lung resection procedures is listed at the bottom of this script) The British Thoracic Society (BTS) guidelines (2001) consider an FEV_1>2 L or >80% predicted to be acceptable for pneumonectomy, and an FEV_1>1.5 L to be acceptable for lobectomy without any additional testing. However, there is no clearly accepted lower threshold for FEV_1. The BTS guidelines were based on relatively old outcomes data, and surgical care has improved since then.

Question 6: When is there value in predicting postoperative pulmonary function, and how is it done?

If patients do not fall into the low-risk category noted above (both FEV_1 and DLCO>80%), then it may be helpful to estimate postoperative pulmonary function based upon the preoperative values, how much lung is being resected, and what is its likely contribution to pulmonary function. The contribution of resected lung to pulmonary function can be estimated by number of segments to be removed or by perfusion lung scanning, which quantifies the perfusion to the resected area of lung relative to perfusion of the lung that will be remaining postoperatively. The perfusion method is recommended for predicting postoperative lung function after pneumonectomy, whereas the anatomic method (using the number of segments to be removed) is recommended for lobectomy.

Although a predicted postoperative FEV_1>0.8 L has been used in the past as a threshold value, using an absolute FEV_1 level can be problematic depending upon size of the patient, gender, etc (Miller JI, J Thoracic Cardiovasc Surg 1993). A better option is to use a threshold value that is a percent of the patient's predicted pulmonary function. In one paper by Alam NZ that reviewed lung resection in patients with marginal function, the following findings were described[20]:

- PPO FEV1 < 30% - All patients developed respiratory failure or died
- PPO FEV1 < 35% - 70% patients experienced complications
- PPO FEV1 < 40% - 50% mortality
- PPO FEV1 >40% - No mortality

A predicted postoperative DLCO less than 40% predicted even in the setting of a normal FEV1 has been shown to be associated with higher post operative complications.(Markos, et al. Am Rev Respir Dis, 1989).

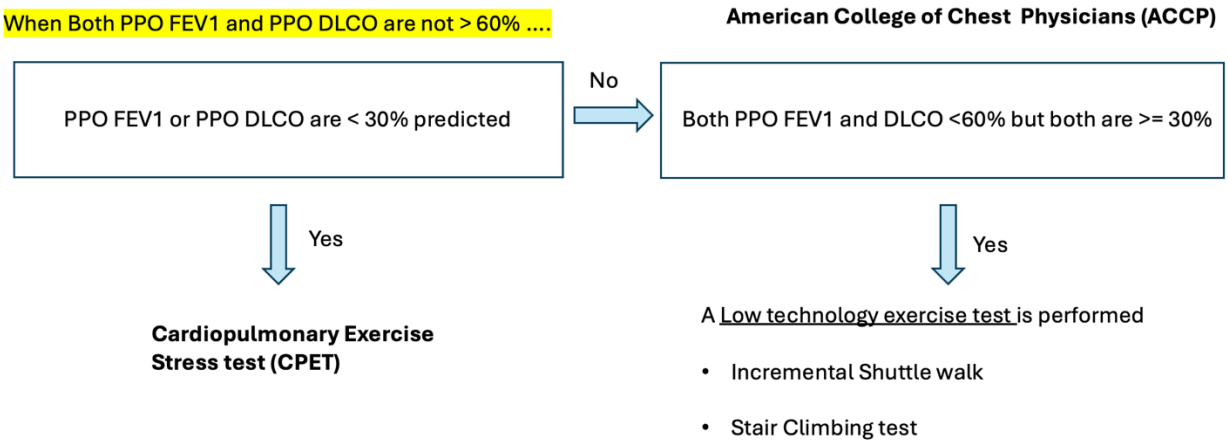
However, it must be remembered that all methods tend to ***OVER ESTIMATE*** long term loss of lung function and currently available equations predicting postoperative lung function are only valid 1-3 months after surgery. These values should not be used in isolation as the

"volume reducing effect" is beneficial and desired in patients with emphysema who undergo volume reduction.

Question 7: When does further testing need to be done?

The ACCP recommends that no further testing needs to be done if both predicted postoperative FEV_1 and predicted postoperative DLCO are >60% of the predicted normal value. If one or the other is <60% but >30%, then a "low technology exercise test" (either a stair climb or an incremental shuttle walk test) is recommended. If either FEV_1 or DLCO is <30%, then a formal cardiopulmonary exercise test is recommended with measurement of maximal O_2 consumption (a.k.a., VO_2max).[21] This is summarized in Figure 3.

Figure 3. Exercise Test Based on Predicted Post Operative FEV_1 and DLCO



Courtesy of and created by the authors based on the work by Brunelli A, et al, CHEST 2013.

Question 8: How are the stair-climb and the incremental shuttle walk tests performed?

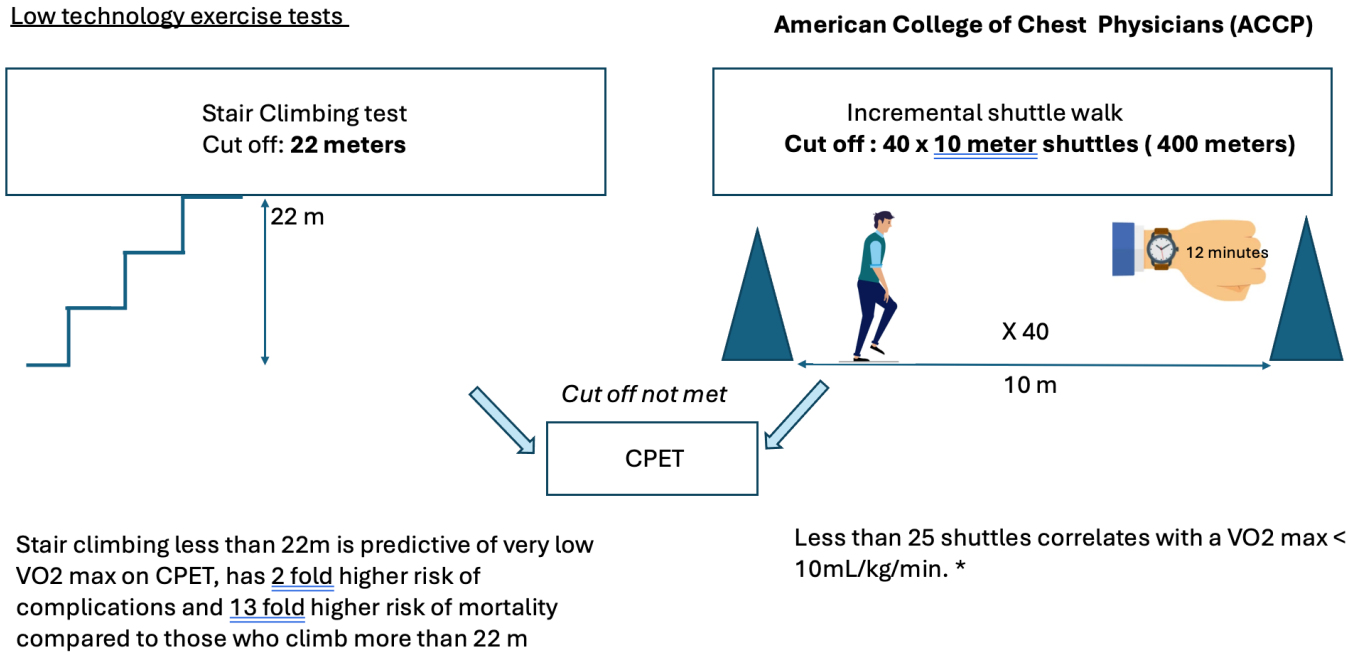
Stair climb

ACCP uses a cutoff of 22 meters of stair climbing as predictive of high risk. If the patient is unable to climb 22 meters, then a cardiopulmonary exercise test is recommended.

Incremental shuttle walk test

Walking at progressively increasing speed for 12 minutes between cones placed 10 meters apart. Cutoff is being able to do 400 meters. If unable to do so, then a cardiopulmonary exercise test is recommended. This is summarized in Figure 4.

Figure 4. Low Technology Exercise Tests



Created by the authors based on the work by Brunelli A, et al, CHEST 2013

Question 9: What is the role of formal cardiopulmonary exercise testing (CPET)?

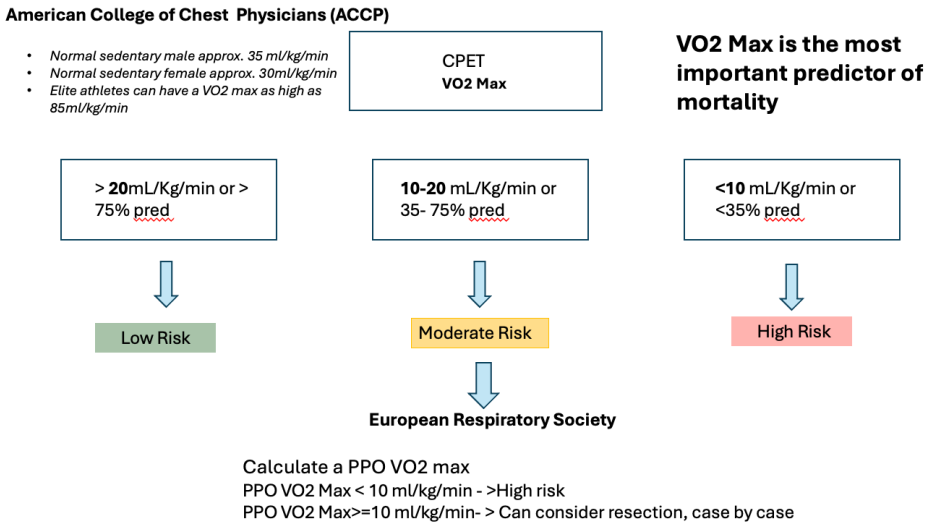
Indications for CPET:

1. When patient's risk is not clearly defined from previously obtained studies.
2. When patient fails to meet the threshold in a low technology exercise test.
3. As an alternative to low technology exercise test.
4. Patient identified as high risk on cardiac evaluation.

Maximal VO_2 (VO_2max) is the measurement used to assess risk: $VO_2max>20$ mL/kg/min is considered acceptable for any type of resection, including pneumonectomy. $VO_2max<10$ mL/kg/min is considered to be high risk and unacceptable for lung resection. If the VO_2max is between 10 and 20 mL/kg/min, the predicted postoperative VO_2max should be calculated (European Respiratory Society, ERS): if <10 ml/kg/min, resection correlates with a high risk of mortality and long-term disability for major anatomic resection and ideally should not be done; if >10 ml/kg/min, a shared decision-making process (with explanation of risk) should be used with the patient (Figure 5).

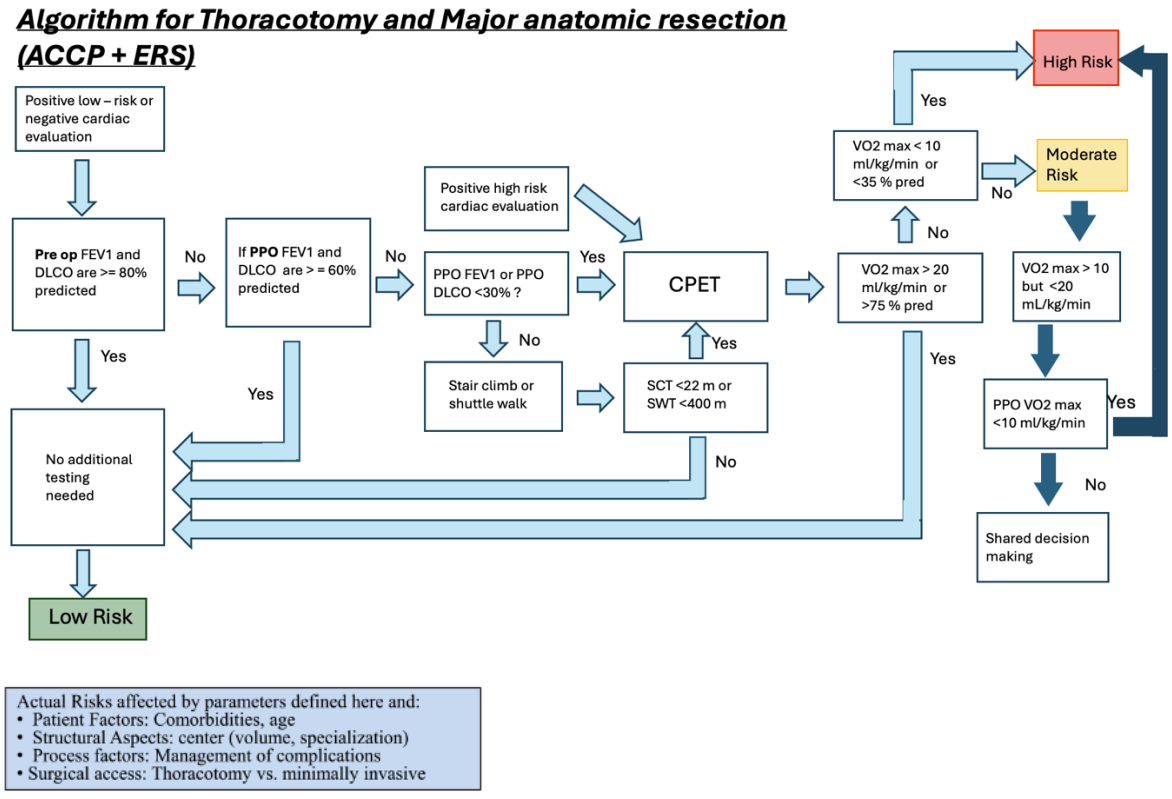
A summary of the decision-making algorithm for lung resection is seen in Figure 6.

Figure 5. Risk Stratification for Lung Resection Using VO_2 Max



Courtesy of and created by the authors based on the work by Brunelli A, et al, CHEST 2013 and Brunelli A, et al, ERJ 2009

Figure 6. Risk Stratification Algorithm for Lung Resection



Courtesy of and created by the authors based on the work by Brunelli A, et al, CHEST 2013 and Brunelli A, et al, ERJ 2009.

Definition of risk for lung resection surgery:

- Low risk: Expected risk of mortality less than 1%. Major anatomic resection can be safely performed.
- Moderate risk: Mortality and morbidity depends on split lung function, exercise tolerance, extent of resection. Risks and benefits should be thoroughly discussed with patient
- High risk: Risk of mortality after standard resection may be greater than 10%. Considerable risk of severe cardiopulmonary morbidity and residual functional loss. Alternative surgical or non-surgical options should be considered.

References:

1. Subramani, Yamini, et al. "Preoperative Evaluation." *Anesthesiology Clinics*, vol. 36, no. 4, 2018, pp. 523–538., https://doi.org/10.1016/j.anclin.2018.07.004.
2. Smetana GW et al. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. Ann Intern Med 2006; 144(8):581.
3. Arozulla AM, Daley J, Henderson WG, Khuri SF. Multifactorial risk index for predicting postoperative respiratory failure in men after major noncardiac surgery. The National Veterans Administration Surgical Quality Improvement Program. Ann Surg 2000; 232:242.
4. Canet J, Gallart L, Gomar C, et al. Prediction of postoperative pulmonary complications in a population-based surgical cohort. Anesthesiology 2010; 113(6):1338-50.
5. Serejo LG, da Silva-Júnior FP, Bastos JP, et al. Risk factors for pulmonary complications after emergency abdominal surgery. Respir Med. 2007 Apr;101(4):808-13. doi: 10.1016/j.rmed.2006.07.015. Epub 2006 Sep 8.
6. Attaran S, McShane J, Whittle I, Poullis M, Shackcloth M. A propensity-matched comparison of survival after lung resection in patients with a high versus low body mass index. Eur J Cardiothorac Surg. 2012 Oct;42(4):653-8. doi: 10.1093/ejcts/ezs135. Epub 2012 Apr 19. PMID: 22518036.
7. Schmid, Marianne, et al. "Impact of Smoking on Perioperative Outcomes after Major Surgery." *The American Journal of Surgery*, vol. 210, no. 2, 2015, https://doi.org/10.1016/j.amjsurg.2014.12.045
8. Hawn MT, Houston TK, Campagna EJ, Graham LA, Singh J, Bishop M, Henderson WG. The attributable risk of smoking on surgical complications. Ann Surg. 2011 Dec;254(6):914-20. doi: 10.1097/SLA.0b013e31822d7f81. PMID: 21869677
9. Mills E, Eyawo O, Lockhart I, Kelly S, Wu P, Ebbert JO. Smoking cessation reduces postoperative complications: a systematic review and meta-analysis. Am J Med. 2011 Feb;124(2):144-154.e8. doi: 10.1016/j.amjmed.2010.09.013. PMID: 21295194.
10. Turan, Alparslan, et al. "Effect of Various Durations of Smoking Cessation on Postoperative Outcomes." *European Journal of Anaesthesiology*, vol. 35, no. 4, 2018, pp. 256–265., https://doi.org/10.1097/eja.0000000000000701.
11. Kabalin CS, Yarnold PR, Grammer LC. Low complication rate of corticosteroid-treated asthmatics undergoing surgical procedures. Arch Intern Med. 1995 Jul 10;155(13):1379-84. PMID: 7794086.
12. Minai, Omar A., et al. "Perioperative Risk and Management in Patients with Pulmonary Hypertension." *Chest*, vol. 144, no. 1, 2013, pp. 329–340., https://doi.org/10.1378/chest.12-1752.
13. Abdelsattar ZM et al. The Impact of Untreated Obstructive Sleep Apnea on Cardiopulmonary Complications in General and Vascular Surgery: A Cohort Study. Sleep 2015; 38(8) 1205-1210.
14. Patel, Nina M., et al. "Preoperative Evaluation of Patients with Interstitial Lung Disease." *Chest*, vol. 156, no. 5, 2019, pp. 826–833., https://doi.org/10.1016/j.chest.2019.05.028.
15. Broaddus CV, Mason RJ, King Jr ,TE et al. *Murray and Nadel's textbook of Respiratory Medicine* 6th ed. Elsevier, 2016
16. Block BM, Liu SS, Rowlingson AJ, Cowan AR, Cowan JA Jr, Wu CL. Efficacy of postoperative epidural analgesia: a meta-analysis. JAMA. 2003 Nov 12;290(18):2455-63. doi: 10.1001/jama.290.18.2455. PMID: 14612482

17. Coccolini F, Catena F et al. Open versus laparoscopic cholecystectomy in acute cholecystitis. Systematic review and meta-analysis. Int J Surg. 2015;18:196. Epub 2015 May
18. Chung F, Yang Y, Brown R, Liao P. Alternative scoring models of STOP-bang questionnaire improve specificity to detect undiagnosed obstructive sleep apnea. J Clin Sleep Med. 2014 Sep 15;10(9):951-8. doi: 10.5664/jcsm.4022.
19. Brunelli A, Ferguson MK, Salati M, et al.Thoracic Revised Cardiac Risk Index Is Associated With Prognosis After Resection for Stage I Lung Cancer. Ann Thorac Surg. 2015 Jul;100(1):195-200. doi: 10.1016/j.athoracsur.2015.03.103. Epub 2015 May 21.
20. Alam NZ. Lung resection in patients with marginal pulmonary function. Thorac Surg Clin. 2014 Nov;24(4):361-9. doi: 10.1016/j.thorsurg.2014.07.004. Epub 2014 Sep 11. PMID: 25441129
21. Brunelli A, Kim AW, Berger KI, Addrizzo-Harris DJ. Physiologic evaluation of the patient with lung cancer being considered for resectional surgery. Diagnosis and management of lung cancer, 3rd ed: American College ofChest Physicians evidence-based clinical practice guidelines. CHEST. 2013; 143 (suppl):e166S-e190S).
22. Brunelli A, Charloux A, Bolliger CT, et al.European Respiratory Society; European Society of Thoracic Surgeons Joint Task Force on Fitness For Radical Therapy. The European Respiratory Society and European Society of Thoracic Surgeons clinical guidelines for evaluating fitness for radical treatment (surgery and chemoradiotherapy) in patients with lung cancer. Eur J Cardiothorac Surg. 2009 Jul;36(1):181-4. doi: 10.1016/j.ejcts.2009.04.022. Epub 2009 May 27.

Preoperative Pulmonary Evaluation

Post-Test Case Related Questions

1. You are seeing a 55-year-old man with a history of asthma (controlled on inhaled steroids), OSA, obesity and diabetes for a pre-operative risk assessment before upcoming cholecystectomy for abdominal pain related to cholelithiasis. On exam he is well appearing, with normal vitals and a peripheral oxygen saturation of 97% on room air. Which of the following factor(s) in this patient would be associated with increased post-operative pulmonary complications?
    a. Asthma
    b. Age
    c. Site of surgery
    d. All of the above
    e. A & B
    f. B & C

2. According to published guidelines which of the following tests should be performed prior to surgery to help with risk stratification?
    a. PFTs
    b. 6MWT
    c. ABG
    d. All of the above
    e. None of the above

3. You are seeing a 72-year-old man with COPD and a 3.5 cm lung mass in the right apex found to be adenocarcinoma. He has no evidence of distant spread and thus he is being considered for possible lobectomy. You order PFTs that show an FEV_1 (1.8 L) 65% predicted with a DLCO 62% predicted. His emphysema is centrilobular and involves both apices. Which of the following is true regarding this patient's candidacy for surgical resection?
    a. There is no clear consensus on absolute cutoffs for candidacy based on PFTs.
    b. His FEV_1 would disqualify him from candidacy.
    c. His DLCO would disqualify him from candidacy.
    d. Both the FEV_1 and DLCO would disqualify him from candidacy.