Pre-operative Pulmonary Risk Stratification
DM Seminar

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16th Feb. 2018

Topics of discussion

- Introduction
- Postoperative Pulmonary Complications (PPCs)
- Changes in Pulmonary Function with Surgery
- Factors Associated with Development of PPCs
- Elements in preoperative evaluation
- Preoperative Pulmonary Preparation and postoperative measures
- Considerations in thoracic surgery
- Risk prediction tools
- Take home message

Preoperative Pulmonary Assessment

Evaluation for **determining** pulmonary **risk** to patient of proposed procedure & **minimising known risk** by:

- Identifying unrecognised pulmonary comorbidity & risk factors for complications of surgery
- Optimising preoperative pulmonary condition in known chronic lung disease
- Treat concomitant medical issues, with goal of optimizing patient outcomes
- Working effectively as member of preoperative team→ Plan intraoperative and postoperative management
- Recognising & treating potential pulmonary complications

Postoperative Pulmonary Complications (PPCs)

- Contribute to perioperative morbidity and mortality
- Incidence: **2% to 19%** in nonthoracic and **19% to 59%** in thoracic
- Postthoracic surgery patients have higher risk for PPCs than patients having upper or lower abdominal surgeries (**19% to 59% compared to 16% to 17% and 0% to 5%,** respectively)
- PPCs after lung resection are major contributing factor to **postoperative deaths**, up to 84% of all deaths
- PPCs have disproportionate impact on hospital costs
- Estimation of the risk should be standard element of all preoperative medical evaluations

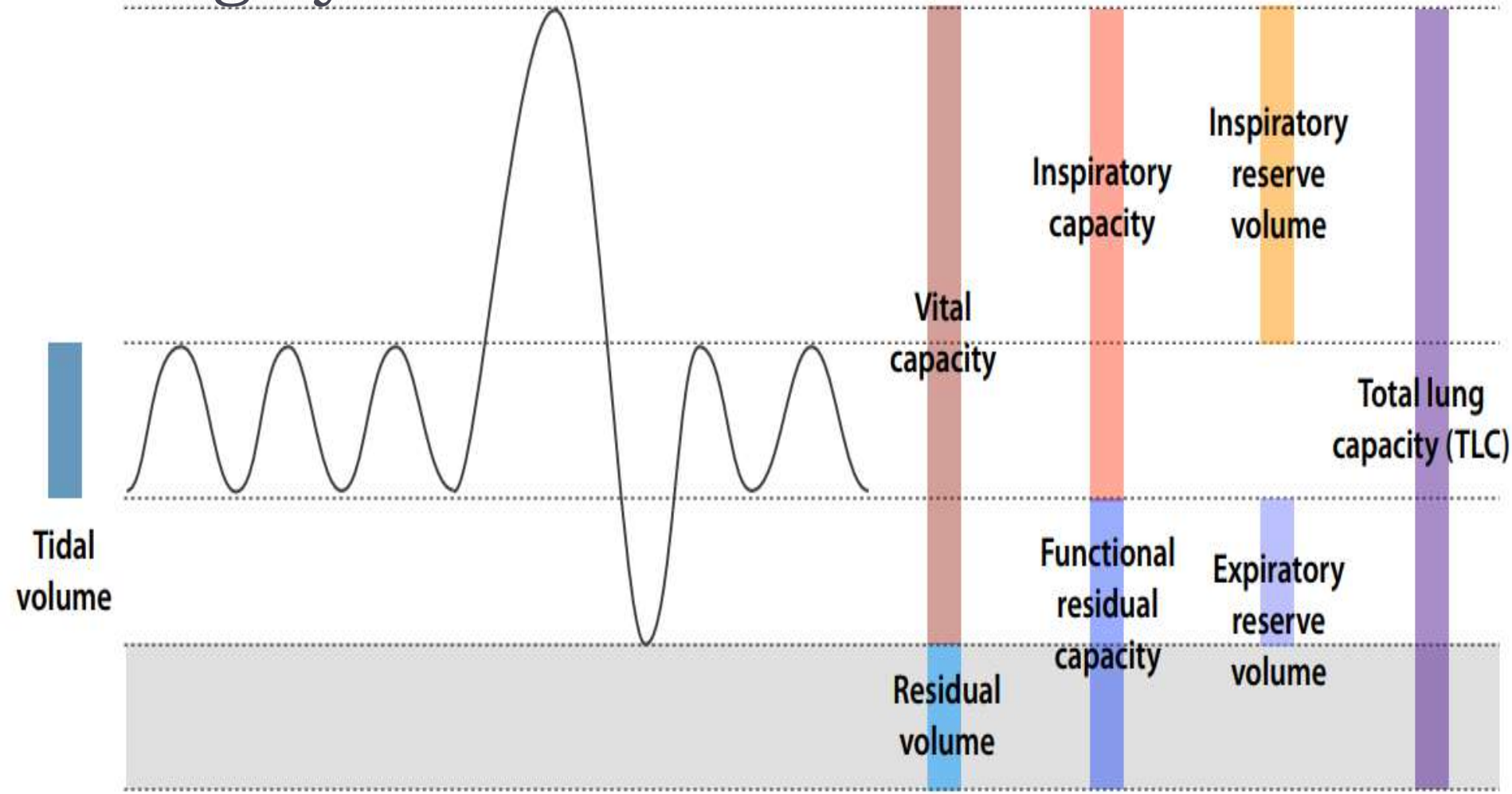
Agostini P. et al. Thorax 2010; 65(9):815–818
Yang CK.. et al. J Surg Res. 2015 Oct;198(2):441-9

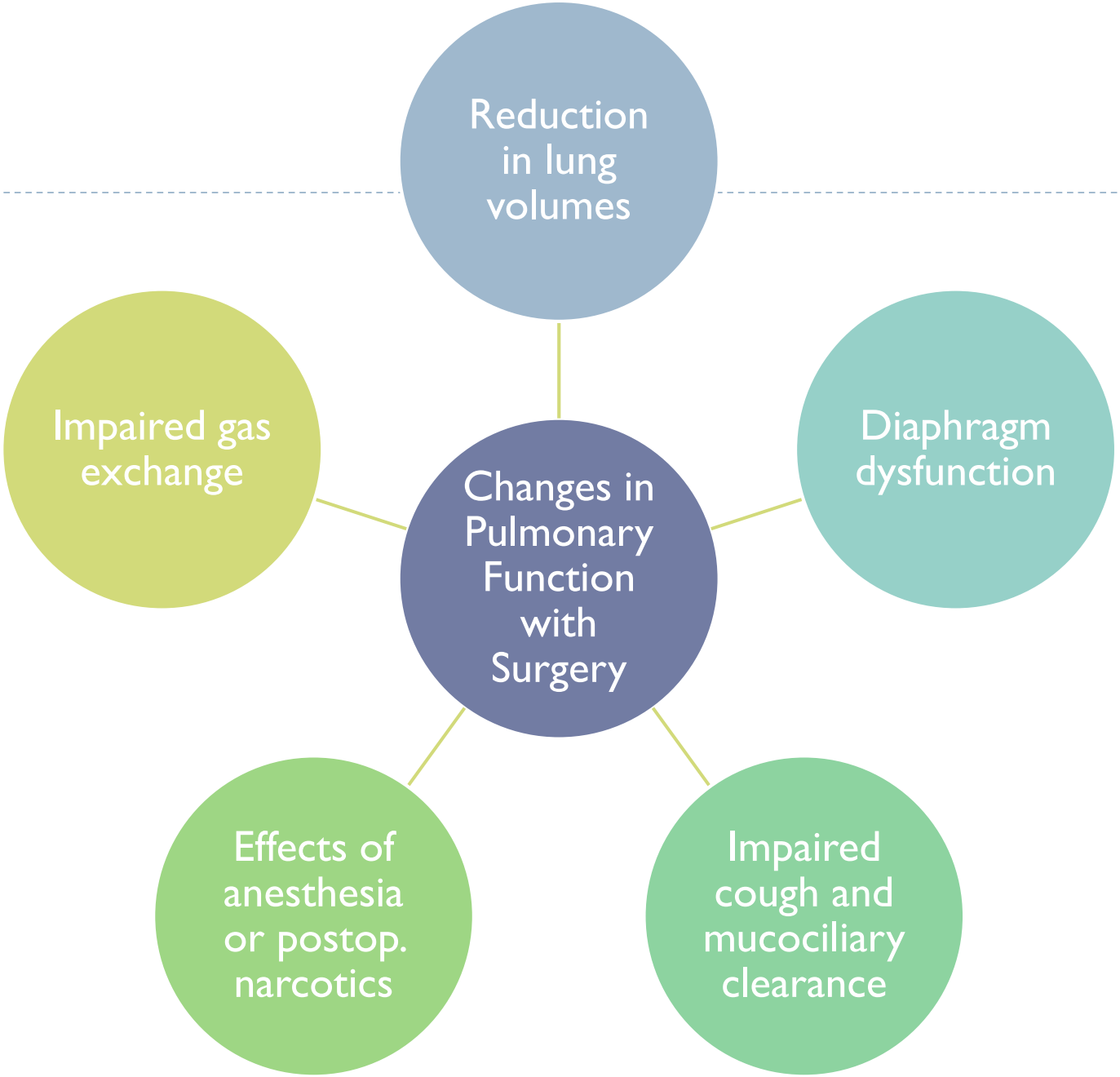
Postoperative Pulmonary Complications (PPCs)

1. Nosocomial **pneumonia** (bacteriologically confirmed)
2. Lobar or whole lung **atelectasis**
3. **Acute respiratory failure**: mechanical ventilation for > 24 hr or reintubation
4. **Prolonged air leak requiring** > 7 days of chest tube drainage
5. **Pulmonary embolism** (confirmed radiographically or on autopsy)
6. **Exacerbation of underlying** chronic lung disease
7. **Bronchospasm**
8. **Aspiration pneumonitis**

Stephas F. et al. Chest 118:1263–1270, 2000

Changes in Pulmonary Function with Surgery




Reduction in lung volumes
Impaired gas exchange
Changes in Pulmonary Function with Surgery
Diaphragm dysfunction
Effects of anesthesia or postop. narcotics
Impaired cough and mucociliary clearance

Reduction in lung volumes

- Abnormalities following thoracic and abdominal surgery is **restrictive**:
  - Characterized by moderate-to-severe **reductions in vital capacity (VC)** and
  - Smaller, **reductions in functional residual capacity (FRC)**
- Degree of impairment similar after upper abdominal and thoracic surgery
- Less for laparoscopic procedures compared with open
- Smaller changes in VC and FRC noted with lower abdominal surgery
- Superficial or extremity surgery: usually not associated with any significant or persistent changes in lung volumes

Ford GT. et al. Clin Chest Med. 1993; 14:237–252
Ali J. et al. Am J Surg. 1974;128:376–382

Reduction in lung volumes

- During **first 24 hours** following upper abdominal surgery, **VC and FRC** may be reduced by **> 70% and 50%,** respectively, and may remain **depressed for > a week**
- Reductions in other lung volumes, including total lung capacity (TLC), inspiratory capacity (IC), expiratory reserve volume (ERV), and residual volume (RV) noted
- Though FEV1 is decreased, ratio of FEV1 to forced vital capacity (FEV1/FVC%) remains unchanged **(obstruction does not occur)**

Fairshter RD. et al. Crit Care Clin. 1987;3:287–306
Meyers JR. et al. Arch Surg. 1975;110:576–583

Reduction in lung volumes

- FRC in early postoperative period usually unchanged from baseline
- Postsurgical **pain** and associated **muscle splinting→ Reduction in FRC→** Impair lung mechanics
- **Diaphragm dysfunction**: an important contributing factor
- Postoperative reduction in FRC is of major physiologic significance

Siafakas NM. et al. Thorax. 1999;54:458–465
Vassilakopoulos T. et al. Am J Respir Crit Care Med. 2000;161:1372–1375

Reduction in lung volumes

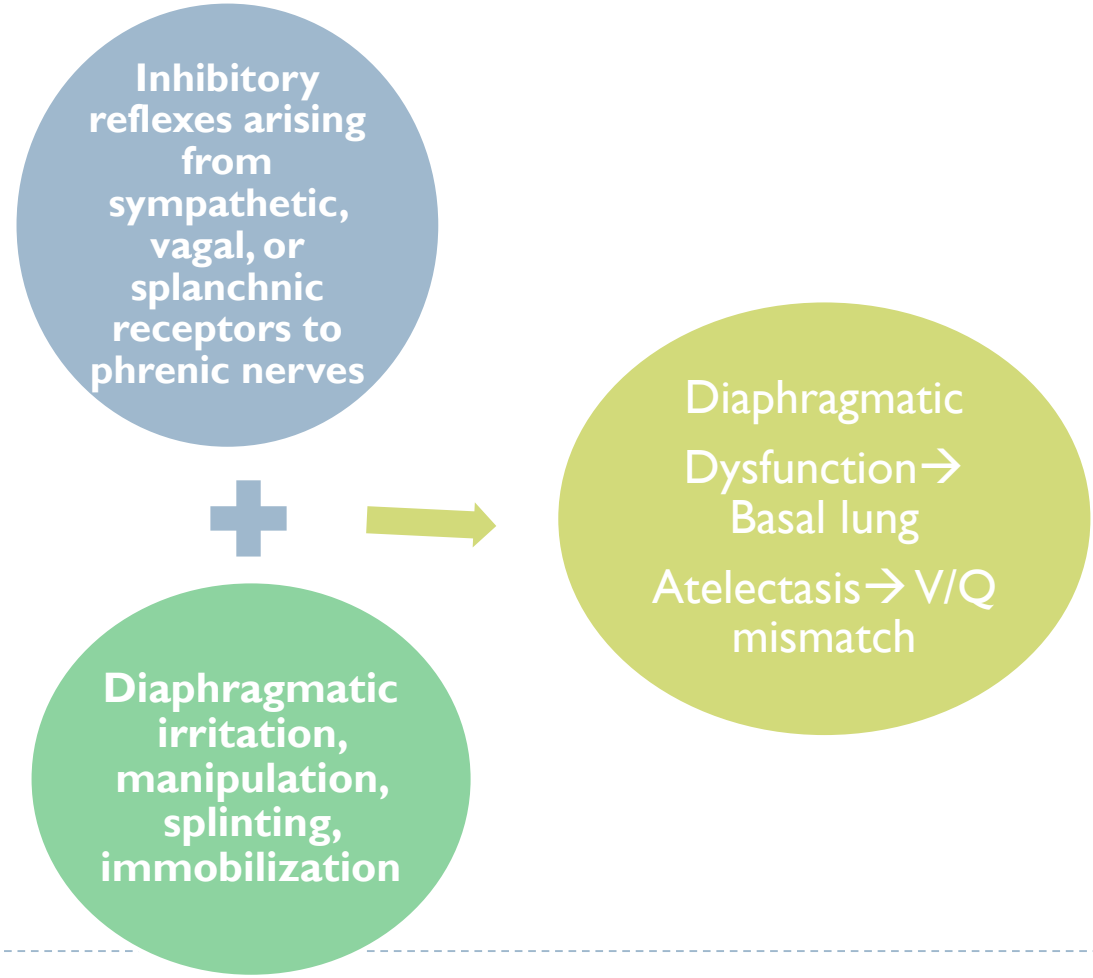
- In normal lung, FRC is always > CC, and airways remain open throughout tidal breath
- When **CC > FRC**, lung volume fails to increase sufficiently during tidal breathing to open all airways→ some alveolar units remain closed during breath→ constitute areas of **atelectasis**
- **Intermediate state** e
volume for part of time
airways open for only p
creating areas of **low v**

Decrease FRC	Increase CC
Supine Position	**Advanced age**
Obesity	**Smoking**
Pregnancy	**COPD**
General anesthesia	**Pulmonary edema**
Abdominal pain	

Perioperative Medicine. New York, McGraw-Hill; 1994

Diaphragm function

Important factor contributing to reduction in lung volumes



Gas exchange

Initial phase:

- **First several hours** following anesthesia and surgery
- Mechanisms related: **Residual effects of anesthesia**, include
  - Ventilation–perfusion mismatch
  - Anesthetic-induced inhibition of hypoxic pulmonary vasoconstriction
  - Right-to-left shunting
  - Alveolar hypoventilation
  - Depressed cardiac output
  - Increased oxygen consumption by peripheral muscles
- **Resolves within 24 hours** following superficial surgery

Gas exchange

Second phase:

- Persist for several **days or weeks**
- Seen after **thoracic and upper abdominal** surgery
- Correlates with **reductions in FRC** and changes in FRC–CC relationship
- Other contributory processes:
  - Alveolar hypoventilation
  - Increased dead space ventilation due to rapid, shallow breathing
  - Decreased mixed venous oxygen tension due to increased oxygen consumption, impaired cardiac output, and reduced oxygen carrying capacity

Control of breathing

Two factors responsible

1. **Residual effects of preanesthetic or anesthetic agents**: Inhibit respiratory drive and reduce ventilatory response to hypercapnia, hypoxia, and acidosis
2. **Narcotics** for postoperative **analgesia**:
   - Depress both hypercapnic and hypoxic ventilatory drives→ decreased TV, reduced MVe, and increased PaCO2
   - Narcotics alter pattern of breathing, reducing frequency of sighs or eliminating entirely
   - In susceptible patients→ precipitate sleep apnea

Kafer ER. et al. Int Anesthesiol Clin. 1977;15:1–38
Weil JV. et al. New Engl J Med. 1975;292:1103–1106

Lung defense mechanisms

- **Cough and mucociliary** transport **– compromised**→ Increased risk of pulmonary infection
- Postoperative pain/ use of narcotics: Inhibit cough
- Altered lung mechanics decrease expulsive force generated with cough
- Mucociliary clearance impaired for upto a week following upper abdominal surgery
- Besides ineffective cough reflex, additional mechanisms involved:
  - Cilia damage from endotracheal intubation and inhalation of dry, hyperoxic gas mixtures
  - Reduced tracheal mucus velocity due to presence of endotracheal tube
  - Anesthetic-induced inhibition of mucociliary transport
  - Atelectasis

Brain JD. et al. Int Anesthesiol Clin. 1977;15:169–198
Fairshter RD. et al. Crit Care Clin.1987;3:287–306

Factors Associated with Development of PPCs:

***Preoperative Factors*:**

- Age
- Chronic obstructive pulmonary disease
- Asthma
- Smoking
- General health status
- Obesity
- Obstructive sleep apnea
- Pulmonary hypertension
- Heart failure
- Upper-respiratory infection
- Metabolic and nutritional factors

***Intraoperative Factors*:**

- Type of anesthesia
- Duration of anesthesia
- Surgical site
- Type of surgical incision
- Emergent nature of procedure

***Postoperative Factors*:**

- Immobilization
- Inadequate pain control

Preoperative Factors: Age

- Early studies suggested **increased risk of pulmonary complications** with advanced age
- Subsequent studies adjusted for health status or pulmonary disease did not reliably demonstrate age as predictor of postoperative complications
- Risk of surgical mortality was similar across age groups when stratified by American Society of Anesthesiologists (ASA) class

Djokovic JL. et al. JAMA. 1979;242(21):2301
Thomas DR. et al. J Am Geriatr Soc. 1995;43(7):811

Age

- Systematic review published from American College of Physicians
- Age >50 years: Important independent predictor of risk
- Healthy older patients carry a substantial risk of PPCs

Age	Unadjusted PPCs estimates range	Median PPCs rate
>65 years	1- 34%	14%
≥70 years	4 - 45%	15%

Age	OR for PPCs (Compared with patients <50 years)
50 to 59 years	1.5 (CI 1.31-1.71)
60 to 69 years	2.28 (CI 1.86-2.80)
70 to 79 years	3.90 (CI 2.70-5.65)
≥80 years	5.63 (CI 4.63-6.85)

Smetana GW. et al. Ann Intern Med. 2006;144:581–595

Age

- In study of resectional lung surgery, despite higher 30-day postoperative mortality in patients >70 years, **incidence of PPCs and hospital stay were not increased, and survival was not decreased**, in older group
- In another case-control study of patients >70 years who underwent lung resection, no significant differences found between elderly and younger controls in **length of stay, major morbidity, or operative mortality**
- Advanced age, should not be the sole reason for withholding surgery, particularly lung resection
- Treatment decisions should be individualized

Sherman S. et al. JAMA. 1987;258:927–930
Cerfolio RJ. et al. Ann Thorac Surg. 2006;82:424–429
Chambers A. et al. Interact Cardiovasc Thorac Surg. 2010;10:1015–1021

Chronic Obstructive Pulmonary Disease

- Incidence of PPCs varies from **10% to >50%**
- Increased incidence of PPCs: **Increase in CC**→ Low ventilation-to-perfusion ratios and **atelectasis**
- Continue to smoke: **Impaired ciliary function and chronic tracheobronchitis**
- Risk for PPCs increase significantly when **FEV1 <65% of predicted**
- Further raised by concomitant **resting hypoxemia**
- Increased risk has been suggested for patients **hypercapnic at rest**, unclear

Milledge JS. et al. Br Med J 1975; 3:670-673
Fuso L et al. Respir Med. 2000;94:1171–1176

COPD

- ? Critical level of lung function below which anesthesia and surgery too dangerous
- Patients with FEV1 as low as 450 mL found to tolerate surgery safely
- Study of 12 very high-risk patients: defined by older criteria of inoperability (FEV_1 <1 liter), only 3 of 15 surgeries associated with postoperative complications and no deaths occurred
- In another study, patients with severe COPD (FEV_1 <50 percent predicted)
  - Mortality was 5.6 % (primarily related after cardiac surgery)
  - Severe PPCs occurred in 6.5%
- Benefit of surgery must be weighed against known risks

Milledge JS. et al. Br Med J 1975; 3:670-673
Williams CD. et al. Am J Surg. 1976;132:763–766
Kroenke K. et al. Arch Intern Med 1992; 152;967

COPD

- Systematic review published from American College of Physicians
- Studies using multivariable→ odds ratio for PPCs attributable to COPD→ 2.36 (CI 1.90-2.93)
- Another observational study using the National Surgical Quality Improvement Program (NSQIP) database including ove
- Unadjusted r

	With COPD	Without COPD
Median hospital stay	4 days	1 day
30 days morbidity rates	25.8%	10.2%
	6.7%	1.4%

	OR	95% CI
Postoperative pneumonia	1.71	1.59-1.83
Reintubation	1.54	1.42-1.66
Failure to wean from ventilator	1.45	1.35-1.56

	OR	*P value*
dity	1.35 (95% CI: 1.30-1.40)	0.0001
ity	1.29 (95% CI:1.19-1.39)	0.0001

Smetana GW. et al. Ann Intern Med. 2006;144:581–595
Gupta H. et al. Chest 2013; 143:1599

Bronchial Asthma

- Well controlled asthma: No link with PPCs
- A large report studied **706 pts** with asthma undergoing general surgery
- **No** incidents of death, pneumothorax , or pneumonia in the sample
- **14 minor complications**: Bronchospasm (12) and laryngospasm (2)
- 1 patient developed postoperative respiratory failure without sequelae
- Controlled asthmatics who have a peak flow measurement of >80% predicted or personal best can proceed to surgery at average risk

Warner DO. et al.Anesthesiology1996 Sep; 85(3):455-6

Bronchial Asthma

- Another recent study compared 24,109 patient with preoperative asthma with 24,109 nonasthma patient
- BA **increased postoperative pneumonia** (OR 1.48; 95% CI 1.34-1.64), septicemia (OR 1.11; 95% CI 1.02-1.21) and UTI (OR 1.17; 95% CI 1.09-1.26)
- 30 days in-hospital **mortality** was increased (OR 1.84; 95% CI 1.11-3.04)
- In another study, 16 patients out of 181 BA had PPCs:14 had asthma attacks and 2 had pneumonia
- Well controlled asthma pose less risk of PPCs

Lin CS, Et al. Medicine (Baltimore).2016
Numata T. et al. Eur Respir J. 2016 Sep;48(suppl 60)

Restrictive lung disease

- Unknown
- Some experience reported with patients having thoracic or corrective orthopedic surgery
- **Higher incidence of PPCs expected** for two reasons:
  - FRC reduced→ Favor formation of areas of poor ventilation and atelectasis
  - Coughing and ability to clear respiratory secretions impaired
- Experience with PPCs reported in three relatively common situations for patients with restrictive disorders:
  - Sarcoidosis complicated by aspergilloma and hemoptysis
  - Corrective surgery for kyphoscoliosis
  - Myasthenia gravis with associated thymoma

Sarcoidosis complicated by aspergilloma and hemoptysis

- Very poor lung function and, usually managed conservatively
- If supportive medical therapy fails, may require thoracotomy and lung resection
- Procedures can be done with low mortality, but they may be complicated by **empyema, chylothorax, prolonged pulmonary parenchymal air leaks, or bronchopleural fistulae**

Akbari JG. Et al. Ann Thorac Surg. 2005; 80:1067–1072
Park CK. Et al. Eur J Cardiothorac Surg. 2008;34:882–885
Brik A. et al. Eur J Cardiothorac Surg. 2008;34:882–885

Corrective surgery for kyphoscoliosis

- Involve anterior or posterior spinal **fusion procedures** or combination of both
- Another important indication for performing procedures: progressive **deterioration of pulmonary function**
- **PPCs** have been reported up to **20%** of patients, including pleural space–related processes (e.g., pneumothorax, pleural effusion, bronchopleural fistula, and empyema) and lobar or total lung atelectasis

Bullmann V. et al. Eur Spine J. 2013;22(Suppl 2): S164–S171
Anderson PR. et al. Acta Anaesthesiol Scand. 1985;129:186–192
Zhang JG. et al. Spine. 2005;30:218–221

Corrective surgery for kyphoscoliosis

- Important risk factors include
  - Nonidiopathic scoliosis
  - Open anterior spinal fusion procedures
  - Age greater than 20 years
  - Mental retardation
  - Preoperative hypoxemia
  - Obstructive PFTs
- **Thoracotomy** associated with significant decrease in pulmonary function for up to 2 years after surgery
- **VATS**: Alternative to open thoracotomy
- Outcomes of anterior fusion via VATS and thoracotomy similar

Bullmann V. et al. Eur Spine J. 2013;22(Suppl 2): S164–S171
Newton PO. Et al. Spine. 2007;32:1875–1882
Lenke LG et al. Spine. 2004;29:2055–2060

Myasthenia gravis with associated thymoma

- **30%** of patients after transsternal approach thymectomy required **MV for >3 days**
- Risk factors for PPCs: Chronic myasthenia gravis (>6 years), severe bulbar weakness, pre-existing respiratory illness, large doses of pyridostigmine, and reduced maximal static expiratory pressure (<50 cm H2O or 66% of predicted)
- Preoperative VC not proved consistent as predictor of respiratory morbidity
- Routine use of plasma exchange in bulbar or generalized MG→ Significantly reduced duration of postoperative ventilatory support and time in ICU
- **VATS- thymectomy**: Increasingly used, with outcomes equivalent or superior to more invasive procedures

Gracey DR. et al. Chest. 1984;86:67–71
Meyer DM. et al. Ann Thorac Surg. 2009;87:385–390
Zahid I. et al. Interact Cardiovasc Thorac Surg. 2011;12:40–46

Smoking

- **Increases risk** of PPCs, even among those without COPD
- Well-documented adverse effects of smoking on respiratory **epithelium and pulmonary function**→ magnitudes **correlate with** degree of **tobacco consumption**
- Individuals undergoing CABG surgery, risk of smoking becomes significant when tobacco use exceeds 20 pack-years
- Statistically significant reduction in complications occurs when patients discontinue smoking for at least 8 weeks prior to surgery
- Abnormalities in pulmonary function persist up to several months after smoking cessation
- Smoking increases risk for thrombosis

Warner MA. et al. Anesthesiology. 1984;60:380–383
Bode FR. et al. Am J Med. 1975;59:43–52

Smoking

- 2 systematic review and one non-randomized study: compared current smoker with those **who stopped smoking prior to surgery**
- Found **lower risk of postoperative complications**, including, wound healing, respiratory complications, overall complications and in-hospital mortality
- Longer pre-operative smoking cessation period reduced the incidence and risk of postoperative complications
- **Maximal effect** in risk reduction of overall and respiratory complications in those who had quit smoking **at least 4 weeks prior to surgery**

Mason DP. Et al. Ann Thorac Surg. 2009 Aug;88(2):362-70
Mills E. et al. Am J Med. 2011 Feb;124(2):144-54
Wong J. et. Al. Can J Anaesth. 2012 Mar;59(3):268-79

Smoking

- In a 2014 meta-analysis of 107 cohort and case-control studies, **preoperative smoking associated with an increased risk of postoperative complications**, including PPCs (RR 1.73, 95% CI 1.35-2.23)
- Associated with increased risk of other postoperative complications as general morbidity, wound complications, general infections, neurological complications and admission to ICU
- However, preoperative smoking was **not associated with postoperative mortality, CV complications**
- Stopping smoking before elective surgery can reduce risk for PPCs, although optimal duration of smoking cessation remains unclear

Gronkaer M. et al. Ann Surg. 2014;259(1):52

Obesity

- Reduce total respiratory compliance by > 60%→ amplified when supine→ Increases work of breathing
- Hence, minute ventilation, oxygen consumption, and carbon dioxide production further increased beyond baseline values, **baseline already elevated** as result of increased metabolic demands imposed by **obese state**
- In terms of gas exchange, modest effects at rest observed only in morbidly obese individuals:
  - Lower than predicted PaO2
  - Higher than predicted alveolar-to-arterial oxygen pressure difference
  - Normal blood oxygen saturation and normal PaCO2

Parameswaran K. et al. Can Respir J. 2006;13:203–210
Zavorsky GS. et al. Obes Surg. 2008;18:1587–1598

Obesity

- **Reduction in ERV** consistent- magnitude of reduction **correlates with degree of obesity**
- Areas of low ventilation relative to perfusion and atelectasis seen
- Also obese patients appear to have larger gastric volume and lower gastric pH→ predisposed to **aspiration**
- But, when bacterial pneumonia, acute respiratory failure, or prolonged MV are considered, and confounding factors are excluded→ obese patients undergoing abdominal surgery do not show an increased incidence of clinically significant PPCs compared with nonobese

Vaughn RW. et al. Anesthesiology. 1975;43:686–689
Reinius H. et al. Anesthesiology. 2009;111:979–987
Blouw EL. et al. AANA J. 2003;71:45–50

Obesity

- Major respiratory complications occur in only **4% to 7%** of morbidly obese patients undergoing gastric bypass surgery
- In absence of concurrent cardiopulmonary disease, risk of PPCs associated with obesity are not excessive
- However, obesity is risk factor for OSA syndrome, which may be unmasked or exacerbated because of use of postoperative analgesics or narcotics

Santry HP. et al. JAMA. 2005;294:1909–1917
Malhotra A. et al. Thorax. 2008;63:925–931

Obesity

- In a **systematic review**, **among eight** studies that adjusted for confounders more common among obese patients, **only one reported** obesity to be a predictor of postoperative pulmonary complication rates
- In recent largest studies to date that used NSQIP database (n = 141,802), pulmonary complications were **no more common among obese adults** (BMI >30 kg/m) than among those with a healthy weight (BMI 18.5 to 24.9 kg/m)
- Unexpectedly, **underweight** patients actually sustained more PPCs

Smetana GW. et al. Ann Intern Med. 2006;144:581–595
Sood A. et al. World J Surg. 2015 Oct;39(10):2376-85

OSAS

- Postoperative respiratory **morbidity: higher** with OSAS than general population
- Use of postoperative **narcotics analgesia** may further blunt ventilatory chemosensitivity
- Initial studies consistent with the expectation
- Subsequent reports failed to show OSAS as significant risk factor for development of major PPCs
- Best to use preoperative evaluation as an opportunity to screen for OSAS

Gupta RM. et al. Mayo Clin Proc. 2001;76:897–905
Nepomnayshy D. et al. Obes Surg. 2013;23:287–291
Ursavaş A. et al. Multidiscip Respir Med. 2013;8:3

OSAS

- In a recent report of 602 patients undergoing bariatric surgery (mean BMI- 42 kg/m^2), clinically significant PPCs (atelectasis and pneumonia) occurred in **1.8%** of patients
- Variables associated with higher risk of PPCs were OSAS (OR 2.3), an abnormal spirometry (OR- 2.6), male gender (OR- 1.9) and preoperative respiratory symptoms (OR- 1.9)
- Using multivariate logistic regression, an **abnormal spirometry was significant predictor of PPCs** in patient with respiratory symptoms and/or OSAS
- Study concluded that in obese patient undergoing bariatric surgery, abnormal preoperative spirometry predicts PPCs only in patients with OSAS

Clavellina-Gaytan D. et al. Obes Surg. 2015 Mar;25(3):530-6

Malnutrition and severe starvation

- Reduced ventilatory response to hypoxia, decreased diaphragmatic muscle function, impaired cell-mediated and humoral immunity, and alterations in elastic properties of lung
- Expiratory muscle weakness (despite preservation of pulmonary function) and increased incidence of PPCs
- Depending on clinical metrics examined (e.g., weight loss >10% over the previous 6 months, BMI <20 kg/m2), screening procedures utilized (e.g., Mini Nutritional Assessment (MNA) score <17), and laboratory tests employed (e.g., serum albumin <36 g/L)→ malnutrition may be found in 50% or > of hospitalized patients
- Aggressive preoperative nutritional support has not been shown to decrease PPCs

Kirkland LL et al. J Hosp Med. 2013;8:52–58
Lunardi AC. et al. Respirology. 2012;17:108–113
N Engl J Med. 1991;325:525–532

Pulmonary hypertension (PH)

- Increases complication rates after surgery, including in patients with mild to moderate pulmonary hypertension
- Potential complications:
  - Hemodynamic instability resulting in severe hypoxemia
  - Acute right heart failure/circulatory collapse
  - Cardiac dysrhythmias
  - Death
- Warrants **careful consideration of indications** for surgery and discussion of potential risks with patients with pulmonary hypertension

Price LC. et al. Eur Respir J. 2013;35(6):1294
Meyer S. et al. Eur Respir J. 2013 Jun;41(6):1302-1307

Pulmonary hypertension (PH)

- Prospective observational study compared 62 patients with PH of any etiology with matched controls
- **Mortality** (9.7% versus 0), postoperative **heart failure** (9.7% vs 0) and **delayed extubation** (21% vs 3%) were significantly higher among patients with pulmonary hypertension
- In a largest in-patient database, perioperative **mortality** for orthopedic patients with PH (n = 3543) was markedly increased compared with matched controls (**OR 3.72**, 95% CI 2.13-6.39 for hip replacement, **OR 4.55**, 95% CI 2.16-9.39 for knee replacement)
- Mortality rate was **2.4% vs 0.6%** in those undergoing THA and **0.9% vs 0.2%** in TKA group

Lai HC. et al. Br J Anaesth. 2007;99(2):184
Memtsoudis SG. et al. Anesth Analg. 2010 Nov;111(5):1110-6

Heart failure

- Risk of pulmonary complications **higher** in patients with heart failure than in COPD
- Suggested by data from systematic review of American College of Physicians→ pooled adjusted OR for pulmonary complications was **2.93** (95% CI 1.02-8.43) for **heart failure** patients and **2.36** (1.90-2.93) for patients with **COPD**
- Original **Goldman cardiac risk** index shown to **predict postoperative pulmonary as well as cardiac** complications
- **Revised Cardiac Risk Index** is more commonly used to estimate risk for cardiovascular complications, validation studies of revised index in **predicting pulmonary complications** have **not been done**

Lawrence VA. et al. Chest. 1996;110(3):744
Smetana GW. et al. Ann Intern Med. 2006;144:581–595

Antecedent respiratory tract infection

- Difficult to predict
- With RSV infections, symptoms resolve in 7 to 10 days; but viral sheds upto 10 to 13 days, may persist beyond 20 days
- **Enhanced airway reactivity and increased airway resistance** associated with RSV and other viral infections may persist for weeks beyond resolution of acute symptoms
- Also, **diaphragmatic function** may be impaired during viral infections

Walsh EE et al. J Infect Dis. 2013;207(9):1424–1432
Lemanske RF Jr. et al. J Clin Invest. 1989;83:1–10
Mier-Jedrzejowicz A. et al. Am Rev Respir Dis. 1988;138:5–7

Antecedent respiratory tract infection

- In pediatric patients, perioperative, nonlife-threatening, **adverse respiratory events more common** in patients with recent (**within 4 weeks**) URTIs compared with those without infections
- In adult population, history of an **acute respiratory infection in month** preceding surgery: Independent risk factor for development of PPCs
- In setting of active or recent respiratory tract infection (in previous 2 weeks), **2- to 4-week delay in elective surgery generally advised**

Rachel Homer J. et al. Paediatr Anaesth. 2007;17:154–161
Canet J. et al. Anesthesiology. 2010;113:1338–1350

General state of health

- Overall health status is an important determinant of pulmonary risk
- Functional dependence and impaired sensorium each increase postoperative pulmonary risk
- Patients with significant preexisting lung disease→ classified in higher ASA class
- **ASA class >2 confers 4.87 fold increase in risk** (95% CI 3.34-7.10)

Smetana GW. et al. Ann Intern Med. 2006;144:581–595

ASA Class	Physical status
ASA I	Otherwise healthy patient undergoing elective surgery
ASA II	Patient with single system or well-controlled disease that does not affect daily life
ASA III	Patient with multisystem or well-controlled major system disease that limits daily activity
ASA IV	Patient with severe, incapacitating disease that is poorly controlled or end stage
ASA V	Patient who is in imminent danger of death and is not expected to survive 24 hours
ASA VI	Patient declared brain-dead patient whose organs are being removed for donor purposes

Relative strength of preoperative risk factors associated with development of PPCs

Risk Factors	Odds Ratio
General state of health (ASA Class >II)	2.55-4.87
Congestive heart failure	2.93
Albumin <3.5 gm/L	2.53
Age >60 years	2.09-3.04
COPD	1.79
Functional dependence	1.65-2.51
Weight loss	1.62
Impaired sensorium	1.39
Cigarette smoking	1.26
Alcohol use	1.21
Antecedent respiratory tract infection	Risk not known
Obesity	No increased risk for major morbidity

Sweitzer BJ. et al. Med Clin N Am. 2009;93(5):1017-1030

Relative strength of intraoperative risk factors associated with development of PPCs

Risk Factors	Odds Ratio
Surgical Site	
Aortic aneurysm repair	6.90
Thoracic surgery	4.24
Abdominal surgery	3.01
Neurosurgery	2.53
Head and neck surgery	2.21
Vascular surgery	2.10
Gynecologic or urologic surgery	Not a risk factor
Hip surgery	Not a risk factor
Procedure-Related Issues	
Duration of surgery >2.5-4.0 hours	2.26
Emergency surgery	2.21
General anesthesia	1.83

Sweitzer BJ. et al. Med Clin N Am. 2009;93(5):1017-1030

Intraoperative risk factors

Emergent basis:

- PPCs are **higher** for surgeries done on an emergent basis
- May be related to loss of ability to implement preventative measures

Duration of anesthesia:

- PPCs increases significantly for procedures lasting longer than 2 to 4 hours
- Patients whose procedures last **4 hours or more are five times more likely** to experience postoperative pneumonia than those whose procedures last <2 hours

Canet J. et al. Anesthesiology. 2010;113:1338–1350
Garibaldi RA. et al. Am J Med. 1981;70:677–680

Type of anesthesia

- Pulmonary effects of general anesthesia implicated in development of PPCs
- **Impairment of oxygenation and carbon dioxide elimination**
- Result from anesthetic-induced changes in shape and motion of **chest wall and diaphragm**, which, in turn, lead to increases in alveolar dead space, shunt fraction, and ventilation–perfusion mismatching
- Alterations in lung function may contribute to pulmonary morbidity

Type of anesthesia

- **Regional anesthesia** (spinal or epidural anesthesia) or **local anesthesia** with monitored anesthesia care (MAC) used as alternatives
- **Epidural anesthesia** to T4 sensory level does not appear to alter FRC, VC, FEV1, alveolar–arterial oxygen gradient, shunt fraction, or cardiac output
- Overall, regional anesthesia→**Decreased risk of PPCs,** and **DVT**
- Beneficial effects most significant for abdominal and thoracic procedures and less for nonthoracoabdominal procedures

Scott NB. Et al. Br J Surg. 1988;75:299–304
Rodgers A. et al. BMJ. 2000;321:1–12
Pompeo E. Semin Thorac Cardiovasc Surg. 2012;24:106–114

Surgical site

- Complication rate (excluding thromboembolic disease) is **< 5%** for gynecologic and urologic procedures, **5% to 10%** for lower abdominal and head and neck surgeries, and **10% to 20% for upper abdominal** surgeries
- Abdominal **aortic surgery** associated with PPCs rate of **>25%**
- Reported postoperative complication rates for **thoracic surgery involving lung resection** vary from under **10% to 40% or higher**

Smetana GW. et al. Ann Intern Med. 2006;144:581–595
Boley TM. et al. Eur J Cardiothorac Surg. 2012;41:14–18

Surgical site

- Postoperative respiratory morbidity following lung resection surgery also depends on number of other issues:
  - Presence of underlying lung disease
  - Amount of functional lung removed
  - Extent to which "bellows" function of lung is impaired
- Potentially **higher incidence of PPCs after lung resection** surgery also reflects occurrence of specific problems related to **entering pleural space or resection of lung tissue** (e.g., development of pleural effusion, empyema, pneumothorax, or persistent pulmonary parenchymal air leak)

Type of surgical incision

- Vertical laparotomy incisions: Higher incidence of PPCs than horizontal incisions
- Abdominal laparoscopic procedures and thoracoscopic lung resection have gained widespread acceptance because of reduced patient discomfort, shortened length of hospitalization, and faster patient return to full activity
- Incidence of PPCs with less invasive procedures is likely to be lower
- Laparoscopic cholecystectomy, demonstrates better preservation and faster recovery of lung volumes, higher arterial oxygen saturations, less postoperative pain and analgesia use, and lower incidence of PPCs
- Comparable findings noted for minimally invasive esophagectomies compared with open procedures, and for VATS versus open thoracotomy

McMahon AJ. et al. Surgery. 1994; 115:533–539

Cao C. et al. Interact Cardiovasc Thorac Surg. 2013;16:244–249

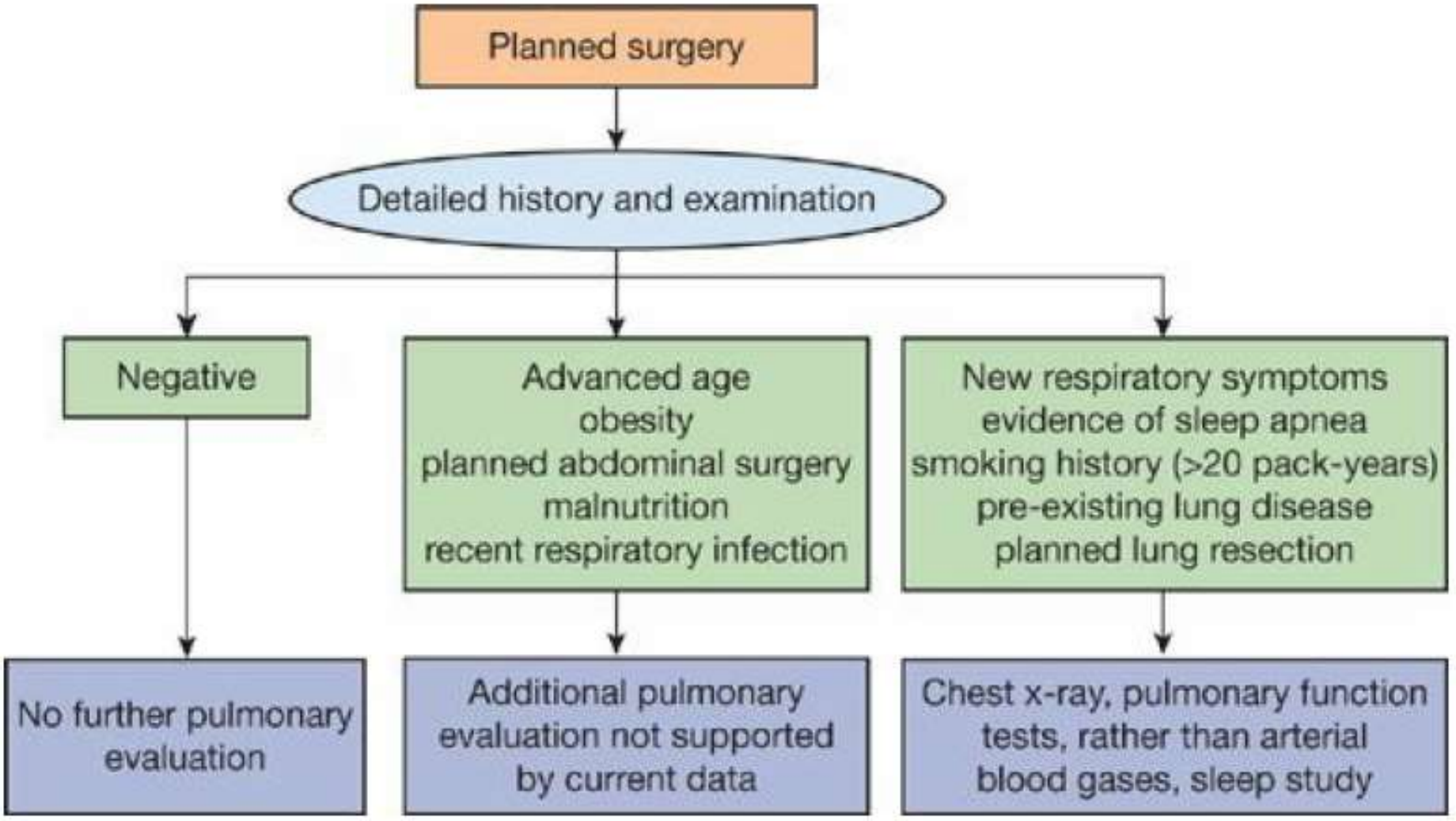
Postoperative risk factors

- Inadequate **pain control, prolonged bed rest**, and patient inactivity contribute to PPCs
- Pain inhibits **coughing and deep breathing and discourages early mobilization**— contribute to increased
- **FRC decreases** by **500 to 1000 mL** in moving from upright to supine position, favoring development of atelectasis
- Increased ambulation: Associated with better clearance of respiratory secretions
- Postoperative immobilization: Major risk factor for development of **DVT and PE**

Foltz BD. et al. Crit Care Clin. 1987;3:269–286

Elements in preoperative evaluation

1. History and physical examination
2. Chest radiograph
3. Arterial blood gas analysis
4. Pulmonary function tests
5. Exercise testings

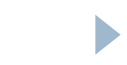

Planned surgery
Detailed history and examination
Negative
Advanced age
obesity
planned abdominal surgery
malnutrition
recent respiratory infection
New respiratory symptoms
evidence of sleep apnea
smoking history (>20 pack-years)
pre-existing lung disease
planned lung resection
No further pulmonary evaluation
Additional pulmonary evaluation not supported by current data
Chest x-ray, pulmonary function tests, rather than arterial blood gases, sleep study

History and physical examination

- Smoking history
- History of respiratory symptoms (e.g., cough, chest pain, dyspnea), including symptoms of sleep apnea
- Extent of pre-existing lung disease
- History of recent respiratory tract infection
- Physical examination rarely helpful in identifying pulmonary risk factors
- When history negative→ physical examination typically unremarkable

Chest radiograph

- Preoperative CXR: usually unrevealing if risk factors and abnormal physical findings absent
- More likely to show **abnormality** in individuals with **known cardiopulmonary disease**, study usually simply confirms presence of previously known abnormalities; only occasionally does it result in alteration in management
- Preoperative chest radiograph **indicated**:
  - When there are new or unexplained symptoms or signs
  - When there is a history of underlying lung disease and no recent chest radiograph
  - When thoracic surgery is planned



Archer C. et al. Can J Anaesth. 1993;40:1022–1027
Smetana GW. et al. Med Clin North Am. 2003;87: 7–40

Arterial blood gas analysis

- **Elevated PaCO2**: increased incidence of postoperative respiratory morbidity in patients with significant **chronic lung disease**→ ABG analysis should be done
- Common practice to obtain an ABG sample in all patients undergoing lung resection surgery, even those without significant underlying lung disease (Supportive data are lacking)
- Serves as basis for comparison with subsequent measurements
- Recommended that an **ABG specimen** be obtained in patients who, by either history or physical examination, have **new significant pulmonary process**
- Data **do not support use of ABG analysis as routine preoperative screening test**

Fuso L. et al. Respir Med. 2000;94:1171–1176
Raffin TA. Ann Intern Med. 1986;105:390–395

Pulmonary function tests

- **Increased risk of PPCs** demonstrated only with **obstructive pulmonary disorders**
- Although expectation of higher incidence of PPCs in patients with restrictive lung diseases, currently, data demonstrating correlation between degree of restriction and postoperative pulmonary morbidity lack
- **Spirometry to evaluate for airway obstruction:** required to screen patients at risk for PPCs

Pulmonary function tests

- Early reviews suggested criteria for increased risk that included the following:
  - FEV1 <70 percent predicted
  - FVC < 70 percent predicted
  - FEV1/FVC ratio <65 percent

- Two reasonable goals that justify use of preoperative PFTs:
  - Identification of group of patients for whom risk of proposed surgery is not justified by benefit
  - Identification of subset of patients at higher risk for whom aggressive perioperative management is warranted

Gass GD. et al. Chest. 1986;89(1):127

Pulmonary function tests

- **Indications for preoperative PFTs**:
  - Presence of cough or unexplained dyspnea
  - History of chronic lung disease
  - History of cigarette smoking (>20 pack-years)
  - Planned lung resection
- Current data **do not support routine use** to evaluate pulmonary risks of **advanced age, obesity, malnutrition, or abdominal surgery**
- **Normal PFTs obviously do not guarantee** complication free postoperative course and do not lessen need for diligent respiratory care following surgery

De Nino LA. et al. Chest. 1997;111:1536–1541
Ramaswamy A. et al. J Gastrointest Surg. 2004;8:159–164

American College of Physicians guidelines

Patient selection for preoperative pulmonary function testing:

- Obtain PFTs for patients with COPD or asthma if clinical evaluation cannot determine if patient is at their best baseline and that airflow obstruction is optimally reduced→ PFTs may identify patients who will benefit from more aggressive preoperative management
- Obtain PFTs for patients with dyspnea or exercise intolerance that remains unexplained after clinical evaluation→Differential diagnosis may include cardiac disease or deconditioning, results of PFTs may change preoperative management
- PFTs should not be used as primary factor to deny surgery
- Not to use preoperative spirometry routinely for predicting risk of PPCs, even prior to abdominal surgery or other high risk surgeries

Qaseem A. et al. Ann Intern Med. 2006;144(8):575

Evaluation for lung resection

- Two broad issues:
- What is the **surgical morbidity and mortality** for the patient with significant underlying chronic lung disease?
- Will **postoperative lung function** be adequate to support a reasonable **quality of life**?

Pulmonary function tests

- Risk of PPCs following **pneumonectomy** increases significantly when **FEV1 <2 L or 80%** of predicted normal, or when maximal voluntary ventilation (MVV) < 50% of predicted
- For **lobectomy**, an **FEV1 of 1.5 L** appears to be critical threshold
- Diffusion capacity for carbon monoxide (DLCO) has also been identified as predictor of postoperative complications
- Increased risk is associated with **DLCO <60% to 80%** of predicted and appears to be independent from FEV1 as predictor of complications, morbidity, and death
- **Predictive postoperative (PPO) lung function should be estimated** for patients with an FEV1 or DLCO <80% of predicted

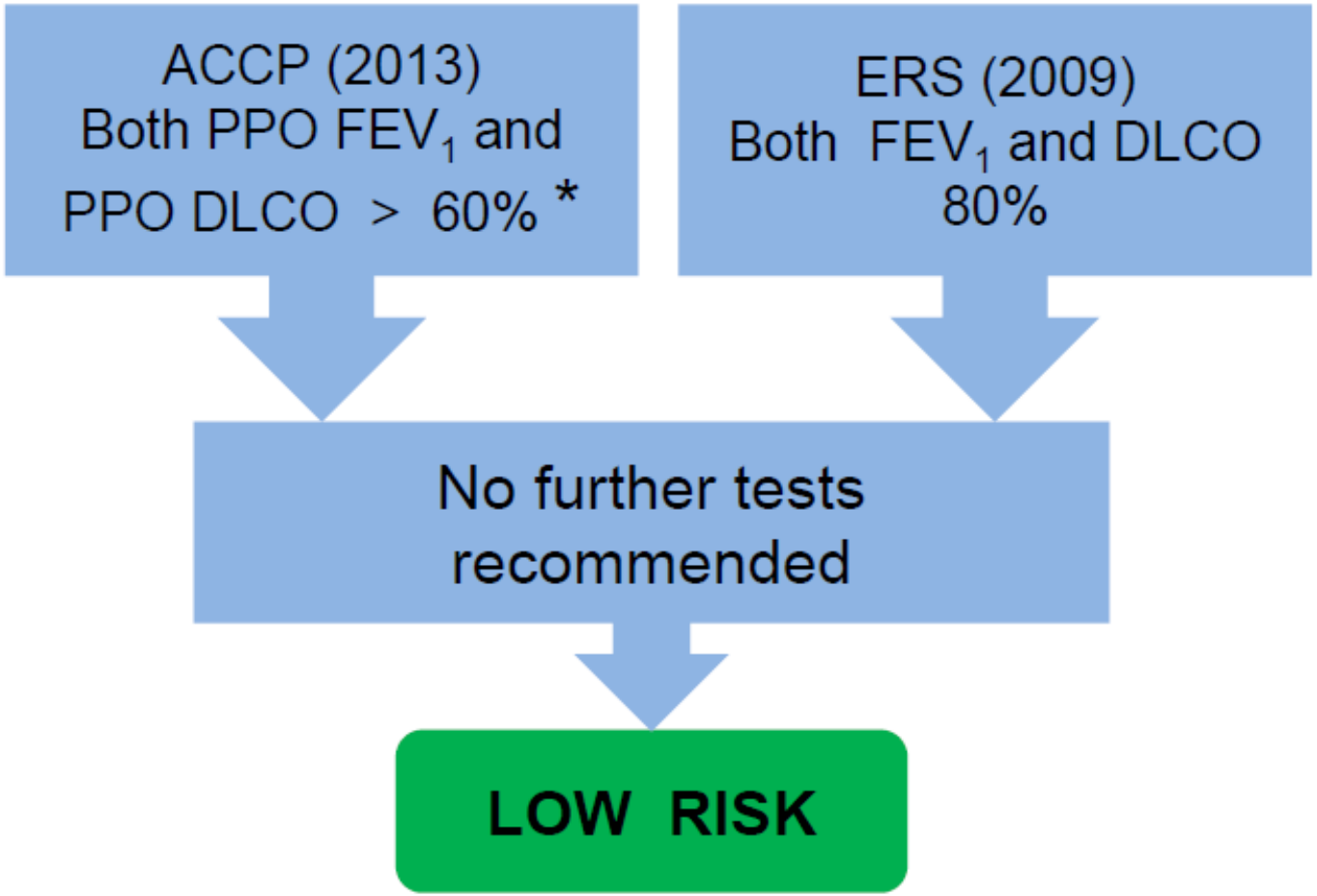
Ferguson MK. et al. Ann Thorac Surg. 2008;85:1158–1165
Loewen GM . et al. J Thorac Oncol. 2007;2:619–625
Colice GL. et al. Chest. 2007;132(Suppl 3):161S–177S
Brunelli A. et al. Eur Respir J. 2009;34:17–41

ALL patients for lung resection

Measure both FEV_1 and DLCO
and
Calculate both PPO FEV_1 and PPO DLCO

ACCP Clinical practice guidelines (3rd edition) 2013

Recommendation: FEV_1 and DLCO



* PPO FEV_1 or PPO DLCO cut off values of 60% predicted values has been chosen based on indirect evidences and expert consensus opinion.

ACCP Clinical practice guidelines (3rd edition) 2013

Estimation of PPO FEV1 and PPO DLCO

Anatomic Method (Segment Counting): only for lobectomy

- PPO FEV1 = preoperative FEV1* x (1 – y/z)

  * *the best measured postbronchodilator value*

- PPO DLCO = preoperative DLCO x (1 – y/z)
  - y = the number of functional or unobstructed lung segments to be removed
  - z = the total number of functional segments

Quantitative Radionuclide Scanning

- To estimate the PPO FEV1 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

Eric L. et al. Thorax 2010;65(Suppl III):iii1eiii27

Estimation of PPO FEV1 and PPO DLCO

Perfusion Method: Calculate predicted postoperative values of FEV1 or DLCO for pneumonectomy

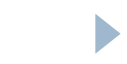
- PPO FEV1= Preoperative FEV1* x (1 – fraction of total perfusion for the resected lung)

  * *the best measured postbronchodilator values*

- PPO DLCO= Preoperative DLCO x (1 – fraction of total perfusion for the resected lung)
- PPO FEV1 and PPO DLCO→ Expressed as a percentage of predicted to calculate % PPO FEV1 and DLCO

Exercise testing

- Measurement of maximal oxygen consumption (**VO2max)** during cardiopulmonary exercise testing (CPET) **useful in predicting postoperative morbidity and mortality**
- VO2max <15 to 20 mL/kg/min is associated with an increased incidence of postoperative complications
- CPET used to further assess operability of patients of who would be at high risk for surgery based on determination of predicted postoperative pulmonary function



Colice GL. et al. Chest. 2007;132(Suppl 3):161S–177S
Win T. et al. Chest. 2005;127:1159–1165

Cardiopulmonary Exercise testing (CPET)

- Sophisticated physiologic testing technique that provides an objective evaluation of functional capacity of both lungs & heart
- Inability to perform preoperative exercise test→ Indication of limited aerobic capacity
- Recommended by guidelines as next step in preoperative risk-assessment process in those patients with compromised pulmonary function
- Standardized CPET using VO2 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 FEV1 or DLCO < 30% or
  - SCT < 22 m or SWT < 400 m
- ERS: CPET recommended when FEV1 or DLCO < 80%

Eric L. et al. Thorax 2010;65(Suppl III):iii1eiii27
ACCP Clinical practice guidelines (3rd edition) 2013

Cardiopulmonary Exercise testing (CPET)

- Risk for perioperative complications has been reported to be higher with lower measured VO2max :
- VO2 max > 20 ml/kg/min or > 75% predicted: can safely undergo planned resection (up to pneumonectomy)
- VO2 max bet
  predicted: inc
  compared wi
- VO2 max of
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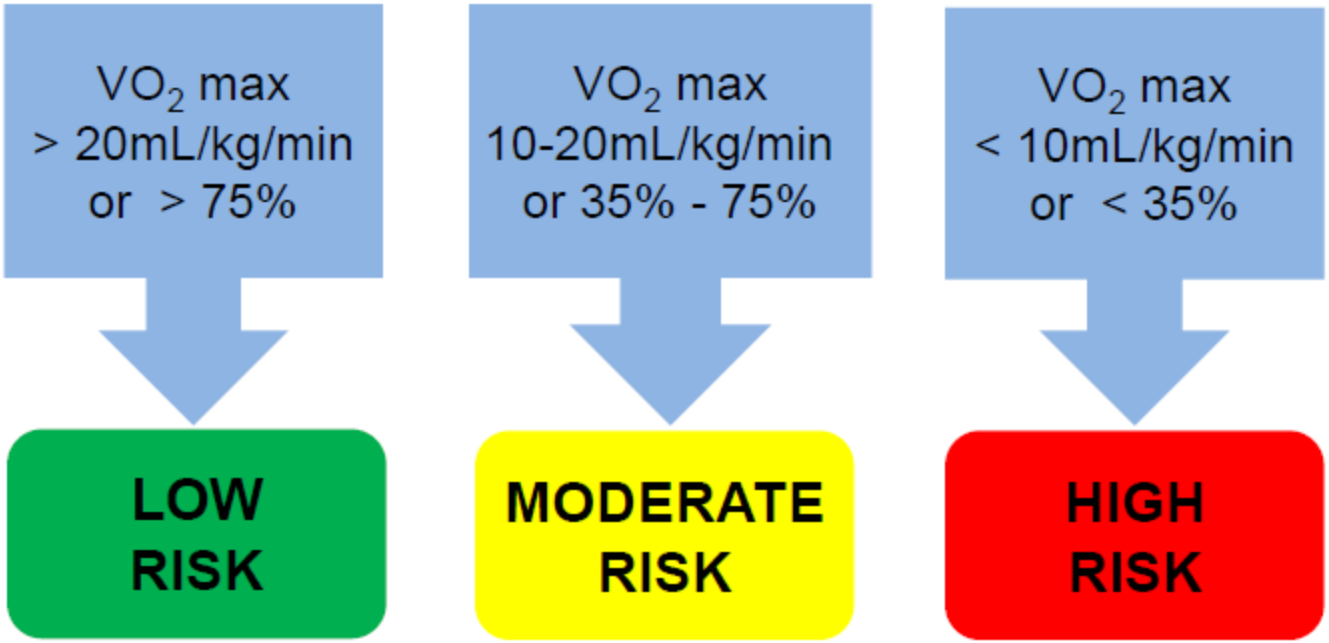

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Exercise testing- Stair climbing test

- Technologically simpler approaches
- Demonstration of patient's ability to climb 5 flights of stairs predicts VO2 >20 mL/kg/min; patients who are unable to climb one flight of stairs have <10 mL/kg/min
- Ability to climb 3 flights of stairs reliably identifies patients who are likely to do well after lobectomy, despite having predicted postoperative FEV1 or DLCO <40% of predicted
- Standardization of stair climbing test may be problematic

Pollock M. et al. Chest. 1993;104:1378–1383
Brunelli A. et al. Chest. 2002;121:1106–1110

Exercise testing- Shuttle walk test

- Investigated as alternatives to CPET
- Submaximal
- *Incremental shuttle walk test (ISWT)*: Patient walks back and forth over distance of 10 m at progressively faster rate for 12 minutes, each 10 m trip is a "Shuttle"
- An ISWT distance >400 m has been associated with VO2 max ≥15 ml/kg/min
- Less than 25 shuttles= Peak VO2 <10 ml/kg/min
- *Endurance shuttle walk test (ESWT)*: Patient walks at constant speed between cones that are 10 m apart, speed selected to be approx 85% of maximal capacity measured from ISWT

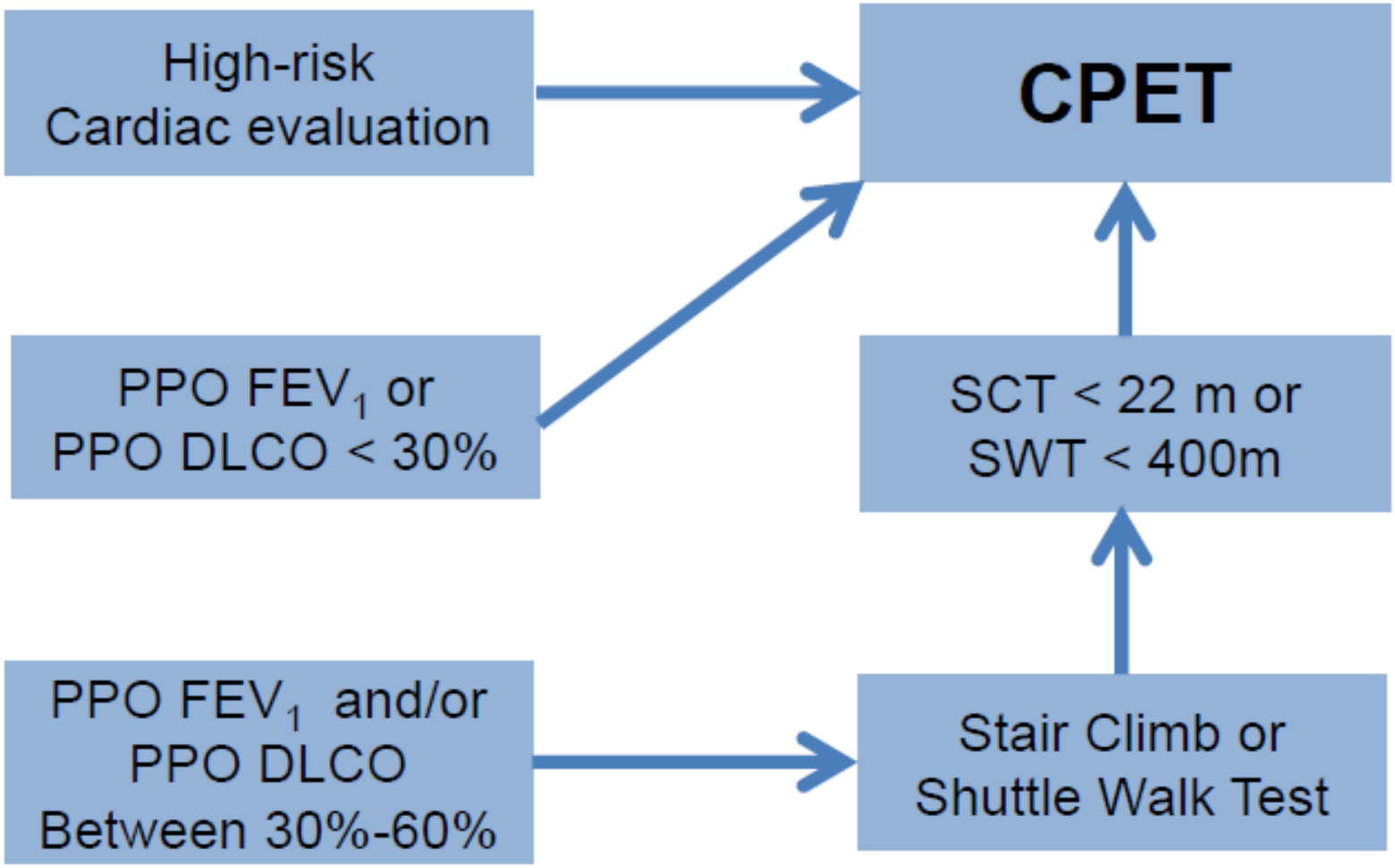
Win T. et al. Thorax. 2006 Jan;61(1):57-60
Parreira VF. et al. Chest. 2014;145(6):1357

Exercise testing- 6-minute walk test

- Rest for 10 min
- Record baseline dyspnea on Borg Scale (1 -10), SpO2 and HR
- Walk at comfortable pace on flat, straight corridor 30 m in length
- Record total distance walked over 6 min
- Post walk Borg Scale, SpO2 and HR recorded
- 6MWD ranges from 400 to 700 m
- A 6-minute walk distance >1000 ft has been reported as predictive of successful surgical outcome

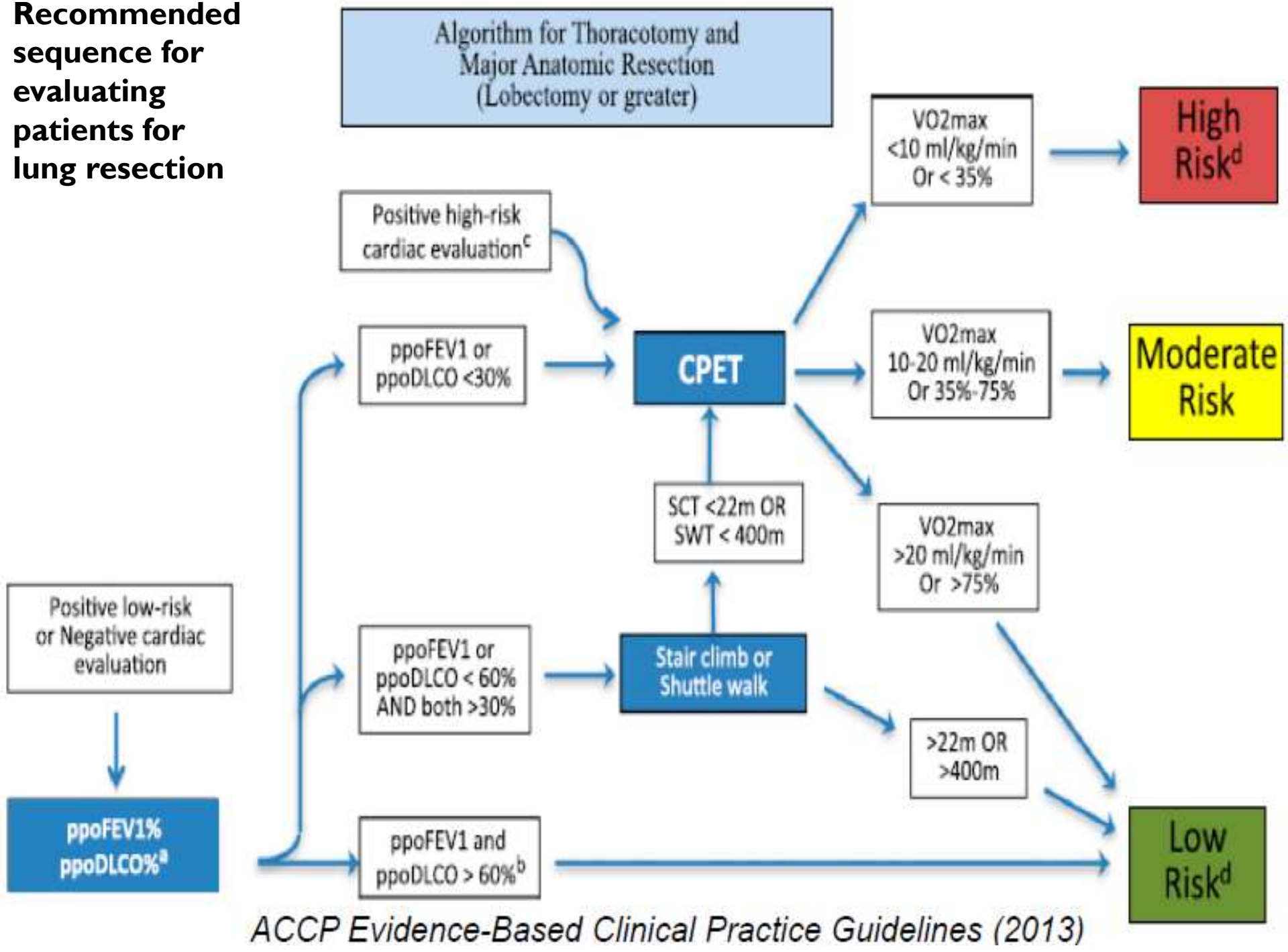
ATS, Am J Respir Crit Care Med 2002;166:111-17

Recommendation: Exercise Tests



ACCP Clinical practice guidelines (3rd edition) 2013

Recommended sequence for evaluating patients for lung resection



ACCP Evidence-Based Clinical Practice Guidelines (2013)

Preoperative Pulmonary Preparation

- Optimization of airway function in patients with obstructive lung disease (bronchodilators; corticosteroids, antibiotics, and chest physiotherapy, when indicated)
- Smoking cessation
- Patient education (deep breathing exercises, importance of coughing and pain control, use of incentive spirometry)
- Consider inspiratory muscle training

Postoperative Measures for Prevention of Respiratory Complications

- Early patient mobilization and ambulation
- Prophylactic lung expansion maneuvers (Incentive spirometry, deep breathing exercises, CPAP)
- Provision of adequate analgesia
- Prophylaxis against thromboembolism

Assessment of postoperative pulmonary risk

- Risk prediction tools use preoperative factors to estimate the risk of postoperative pulmonary complications
- Useful to stratify risk when advising patients before surgery and, in some cases, to identify patients most likely to benefit from risk-reduction interventions
- Patients predicted to be at high risk of postoperative respiratory failure may be scheduled for postoperative care in more intensive care location
- All four risk indices offer advantage of providing a numerical estimate of risk, rather than qualitative category of risk

ARISCAT (Canet) tool

- Offers advantage of use of readily available clinical information and provides an estimate of risk of any PPCs
- Disadvantage of inclusion of minor complications that may not impact outcome or contribute importantly to morbidity
- Assigns weighted point score to seven independent risk factors:
  - Advanced age
  - Low preoperative oxygen saturation
  - Respiratory infection within the past month
  - Preoperative anemia
  - Upper abdominal or thoracic surgery
  - Surgery lasting more than two hours
  - Emergency surgery

Canet J. et al. Anesthesiology 2010 Dec;113(6):1338-50

Factor	Adjusted OR (95% CI)	Risk Score
Age, years: ≤50	1	
51-80	1.4 (0.6-3.3)	3
>80	5.1 (1.9-13.3)	16
Preoperative oxygen saturation		
≥96%	1	
91-95%	2.2 (1.2-4.2)	8
≤90%	10.7 (4.1-28.1)	24
Respiratory infection in last month	5.5 (2.6-11.5)	17
Preoperative anemia- Hb≤10 g/dl	3 (1.4-6.5)	11
Surgical incision: Upper abdominal	4.4 (2.3-8.5)	15
Intrathoracic	11.4 (1.9-26.0)	24
Duration of surgery: ≤2 hours	1	
2-3 hours	4.9 (2.4-10.1)	16
>3 hours	9.7 (2.4-19.9)	23
Emergency surgery	2.2 (1.0-4.5)	8
Risk Class	**No. of point in score**	**Pulmonary complication rate (validation sample)**
Low	<26 points	1.6%
Intermediate	26-44 points	13.3%
High	≥45 points	42.1%

Canet J. et al. Anesthesiology 2010 Dec;113(6):1338-50

ARISCAT (Canet) tool

- Validated in 5099 European population
- Score's discrimination was good: C-statistic (95% CI), 0.8 (0.78-0.82)
- Predicted versus observed PPC rates for low, intermediate and high-risk were 0.87 and 3.39% (score <26), 7.82 and 12.98% (≥26 and <45) and 38.13 and 38.01% (≥45), respectively
- Positive likelihood ratio for score ≥45 was 7.12 (5.93-8.56)

Mazo V. et al. Anesthesiology. 2014;121(2):219

Arozullah respiratory failure index

- Predicts the incidence of postoperative respiratory failure (mechanical ventilation for ≥48 hours)
- Based on several factors, including type of surgery, laboratory results, functional status, history of chronic obstructive pulmonary disease (COPD), and age
- Point scores are stratified into five classes with risk of respiratory failure ranging from 0.5 to 26.6 percent
- Index was based on multivariate analysis of a cohort of 81,719 patients from the National Veterans Administration Surgical Quality Improvement Program and validated on another 99,390 patients
- Too complicated for use in clinical practice
- Likely be of most value in research settings

Arozulla AM. et al. Ann Surg 2000;232:242

Performance of the Arozullah respiratory failure index

Class	Point total	% Respiratory failure
1	≤10	0.5
2	11-19	1.8
3	20-27	4.2
4	28-40	10.1
5	>40	26.6

Arozulla AM. et al. Ann Surg 2000;232:242

Arozullah respiratory failure index

Preoperative predictor	Point value
Type of surgery	
Abdominal aortic aneurysm	27
Thoracic	21
Neurosurgery, upper abdominal, peripheral vascular	14
Neck	11
Emergency surgery	11
Albumin <3.0 g/dL	9
BUN >30 mg/dL	8
Partially or fully dependent functional status	7
History of COPD	6
Age	
≥70 years	6
60-69 years	4

Arozulla AM. et al. Ann Surg 2000;232:242

Gupta calculator for postoperative respiratory failure & pneumonia

- Uses multiple preoperative factors to predict risk of failure to wean from mechanical ventilation within 48 hours of surgery or unplanned intubation/reintubation postoperatively
- Derived from the American College of Surgeons' National Surgical Quality Improvement 2007 data set (211,410 patients for training) and 2008 data set (257,385 patients for validation) using logistic regression techniques to determine the weight of preoperative predictors
- Not possible to perform this calculation manually
- Both the calculator may be downloaded for free, or accessed online

Gupta H. et al. Chest. 2011;140(5):1207
Gupta H. et al. Mayo Clin Proc. 2013 Nov;88(11):1241-9

Prediction scores in thoracic surgery

- **Thoracoscore:** developed in France using data obtained from more than 15,000 patients who were enrolled in a nationally representative thoracic surgery database
- Authors identified **nine factors** that predicted increased mortality: age, sex, dyspnea score, American Society of Anesthesiologists status, performance status, priority of surgery, diagnosis, procedure class, and comorbid disease
- Subsequently validated in the United States and incorporated into the British Thoracic Society guidelines for risk assessment of patients with lung cancer

Falcoz PE. et al. J Thorac Cardiovasc Surg. 2007;133(2):325–332
Lim E. et al. Thorax 2010;65(Suppl 3):iii1–iii27

Prediction scores in thoracic surgery

- More recent studies have found Thoracoscore to have lower predictive power than reported earlier
- Kozower and colleagues reported **another model** of perioperative risk for mortality and major morbidity from a database of >18,000 patients—the *Society of Thoracic Surgeons* ***(STS)*** *General Thoracic Database*
- **Found12 risk factors** to be associated with mortality, including American Society of Anesthesiologists status, the Zubrod functional status scale, renal dysfunction, induction chemoradiation, *FEV1*, *BMI* (an increase was protective), male sex, and importantly, the type of surgery (pneumonectomy and bilobectomy had significantly higher mortality risks)

Bradley A. et al. Eur Respir J. 2012;40(6):1496–1501
Kozower BD. et al. Ann Thorac Surg. 2010;90(3):875–881

Prediction scores in thoracic surgery

- Limitation of both the Thoracoscore and the STS models: lack of incorporation of *DLCO data into their models*
- Majority of patients in this database did not have measurement of diffusion capacity
- DLCO was found to be a strong independent predictor of mortality, in addition to the factors mentioned previously

Ferguson MK. et al. J Thorac Cardiovasc Surg. 2009;138(6):1297–1302

Take home message

- Detail history and relevant physical examination is required to predict PPCs in most of the cases and to avoid unnecessary investigations
- Those with high risk of PPCs should be evaluated: COPD, OSAS, >60 yrs, ASA≥II, functionally dependent, CHF
- Not significant risk for PPCs: Obesity, mild or moderate asthma
- Those at higher risk for PPCs→ Evaluate for other concomitant risk factors: prolonged (>3 hours), abdominal, thoracic, neuro, head and neck, vascular, aortic aneurysm repair, emergency surgeries, and GA
- Consider laproscopic and minimal invasive surgery whenever available
- Raised BUN (>30 mg/dL), low serum albumin level (<35 g/L), low hemoglobin are also marker of risk of PPCs

Take home message

- Patients at high risk for PPCs should receive preventive preoperative and postoperative measures
- For elective surgery, the goals of preoperative evaluation: stabilizing and controlling underlying lung condition, maximizing lung function, ensuring smoking cessation, and instituting preoperative lung expansion maneuvers
- PFT and CXR not used routinely except in patients with h/o of COPD or asthma
- No role for ABG analyses to identify high risk patients or to deny surgery
- Thoracic surgery needs detail pulmonary function test as provided in guidelines
- Evaluation should be indivisualized
- Patient should be encouraged to stop smoking at anytime prior to surgery