Preoperative pulmonary assessment for non-thoracic surgery

Dr Sarat

INTRODUCTION

It is the evaluation for determining pulmonary risk to the patient of a proposed procedure & minimising known risk by:

- Identifying unrecognised pulmonary comorbid disease & risk factors for complications of surgery
- Optimising preoperative pulmonary condition
- Recognising & treating potential pulmonary complications
- Working effectively as a member of preoperative team

Effect on surgical outcome

- Conflicting findings of effects of consultation on utilisation, cost or perioperative mortality:
  - -a cohort study on hip fracture showed decreased length of stay
  - -another cohort showed equal or increased cost & length of stay
  - -a cohort in neurosurgical case had lower cost but not stay
  - -in neurosurgical patients also, no mortality difference observed after implementation of a hospitalist comanagement service
- No study has shown decrease in perioperative morbidity with medical consultation but it will improve care if recommendations are implemented,assuming that they are evidence based

J Gen Intern Med 1995; 10:671

J Am Coll Sur 2004; 199:531

Arch Intern Med 2010; 170:2004

Why preoperative pulmonary assessment

- Preoperative pulmonary assessment needed to reduce Postoperative pulmonary complications (PPCs);increasingly becoming part of preoperative medical evaluations
- PPCs contribute significantly to perioperative morbidity & mortality
- One fourth of deaths occurring within 6 days of surgery related to PPCs
- In abdominal surgery, pulmonary complications occurred more than cardiac complications ,also with longer hospital stays
- The National Surgical Quality Improvement Program (NSQIP) also found that PPCs are most costly of major postoperative medical complications & resulted in the longest length of stay

Heart Lung 1995; 24:94-115
J Gen Intern Med 1995: 10:671
J Am Coll Surg 2004; 199:531

Definition and magnitude of PPC

- PPCs are pulmonary abnormality producing clinically significant disease/dysfunction that adversely affects clinical course; like:

  -- Atelectasis

  --Infection, including bronchitis and pneumonia

  --Prolonged mechanical ventilation and respiratory failure

  --Exacerbation of underlying chronic lung disease

  --Bronchospasm
- Extension of normal physiologic changes in lung occuring with anesthesia
- Rate of PPCs was 6.8% in a systematic review of studies
- 2-70%--depending on pt. selection,procedure related risk,defininitions

Postgrad Med 1992; 91:167
Chest 1991; 99:923
Ann Intern Med 2006; 144:581

PERIOPERATIVE PULMONARY PHYSIOLOGY

- Reduced lung volume after surgery is major factor in development of PPCs
- Upper abdominal surgery results in restriction & reduction in lung volumes :
  --Vital capacity (VC) is reduced by 50-60% , up to a week
  --Functional residual capacity (FRC) is reduced by about 30%
  --Diaphragmatic dysfunction play the most important role
  --Postoperative pain and splinting also contributes

Anesth Analg 1981; 60:46
Am Rev Respir Dis 1983; 127:431

PERIOPERATIVE PULMONARY PHYSIOLOGY

- Reduction of FRC below closing volumes contributes to risk of atelectasis, pneumonia, and ventilation/perfusion (V/Q) mismatch
- Microatelectasis leads to impaired gas exchange & postoperative hypoxemia
- Decreased tidal volume, loss of sighing breaths,increase in respiratory rate occur after abdominal surgery
- Residual anesthesia & postoperative (POP)opioids depress respiratory drive
- Inhibition of cough ,impairment of mucociliary clearance of secretions
- Lower abdominal surgery is associated with lesser changes
- Reductions in lung volumes not seen with surgery on the extremities

Anesthesiology 1972; 37:178

Br J Surg 1982; 69:734

- PPCs can be discussed under 3 categories—
  A. patient related risk factors
  B. procedure related risk factors
  C. laboratory related risk factors

PATIENT RELATED RISK FACTORS

- The potential patient related factors include the following:

--Age

--Chronic lung disease

--Asthma

--Smoking

--General health status

--Obesity

--Obstructive sleep apnea

--Pulmonary hypertension

--Heart failure

--Upper respiratory infection

--Metabolic factors

Age

- Initial studies suggested increased risk of PPCs with age
- Later studies adjusted for health status or pulmonary disease did not demonstrate age as a predictor of postoperative complications
- But a recent systematic review with adjustment for age-related comorbidities showed

  -- age >50 years was an important independent predictor of risk

  --compared to patients <50 years old,patients aged

  - 50 to 59 years, had odds ratios (OR) of 1.50 (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

  -- so,healthy older patients carry a substantial risk of PPCs

JAMA 1979; 242:2301
Arch Intern Med 1992; 152:967
Ann Intern Med 2006; 144:581

Chronic obstructive pulmonary disease

- In COPD(commonest CLD for PPCs)unadjusted RR of PPCs-- 2.7 to 6.0
- Patients with severe COPD were 6 times more likely to have a major PPCs after abdominal surgery than those without COPD
- Decreased breath sounds,prolonged expiration, rales,wheezes ,or rhonchi correlated with an increased risk for PPCs in one case control study
- In multivariate regression model,predictors of PPCs were age ≥65 (OR 1.8), smoking ≥40 pack-years(OR 1.9), and maximum laryngeal height of≤ 4 cm (distance from the top of the thyroid cartilage to the suprasternal notch at end expiration, known to be an accurate sign of COPD)

N Engl J Med 1999; 340:937
Chest 1996; 110:744
CARE-COAD1 Group ,*JAMA 2000; 283:1853*

- No defined level of pulmonary function below which surgery is C/I :

  --in 12 very high risk patients ,defined by older criteria of inoperability (FEV1 <1 liter),only 3 of 15 surgeries associated with POP complications and there were no deaths

  --In 107 consecutive operations with chronic obstructive pulmonary disease (FEV1 <50% of predicted) PPCs occurred in 31 operations (29%) and were significantly related to the type and duration of surgery

  --there were 6 deaths (5/10 CABG,1/97 non-CABG) and only 2 cases had nonfatal ventilatory failure

Br Med J 1975; 3:345

Arch Intern Med 1992; 152;967

Asthma

- Recent studies find no link for PPCs with well controlled asthma
- Largest 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

Anesthesiology 1996; 85:460

Smoking

- Prospective cohort study of 410 pts undergoing elective, noncardiac surgery found smoking associated with >5 fold increase in PPCs (odds ratio = 5.5)
- Retrospective,multivariate analysis of 4700 pts found smoking associating independently with increased risk of POP ICU admission (odds ratio = 1.55)
- In a systematic review, the pooled odds ratio PPCs for smokers was 1.40 (95% CI,1.17-1.68) among five studies that performed multivariable analysis
- Prospective study of 272 pts.for nonthoracic surgery found in a multivariate regression model that pts. ≥40 pack-years had an OR of 1.9 for PPCs

Anesthesiology 1984; 60:380
Chest 1998; 113:883
Ann Intern Med 2006; 144:581
Am J Respir Crit Care Med 2003;167:741

Smoking ..

- Smokers ≥ 20 pack-year have higher PPCs than those with lesser pack-year
- Current smokers have increased PPCs even without chronic lung disease
- Risk of PPCs with smoking highest in those who smoked within past 2 m
- Patients who stopped smoking for more than six months had rates similar to those who had never smoked (11.1 and 11.9 percent, respectively)

Mayo Clin Proc 1989; 64:609

Obesity

- Review of 10 series of obese gastric bypass patients,showed a 3.9% incidence of pneumonia and atelectasis,similar as in general population
- Prospective report of 1000 patients undergoing laparotomy found obesity, (BMI >25 kg/m2) to be an independent risk factor for PPCs
- Prospective study of 400 patients undergoing abdominal surgery found obesity (BMI >27 kg/m2) to be 1 of 6 independent risk factors for PPCs
- Prospective study of 272 pts for nonthoracic surgery found an OR of 4.1 with BMI ≥30 kg/m2 for PPCs;multivariate model negates it to be a factor
- A systematic review found that, among eight studies using multivariate analysis, only one study identified obesity as an independent predictor

Ann Intern Med 1986; 104:540
Chest 1991; 99:923
Chest 1997; 111:564
Am J Respir Crit Care Med 2003; 167:741
Ann Intern Med 2006; 144:581

Obesity..

- Changes in obesity including reduction in lung volumes,V/Q mismatch, and relative hypoxemia,are expected to increase with anesthesia
- But studies show mixed results in obesity as a risk factor for PPCs
- Overall obesity is not a significant risk factor for PPCs and should not affect patient selection for high-risk procedures

Ann Intern Med 1986; 104:540

Obstructive sleep apnea

- Obstructive sleep apnea (OSA) increases PPCs including early hypoxemia, unplanned reintubation,& influences pneumonia or respiratory failure
- OSA is common amongst pts. undergoing operations like bariatric surgery
- Adverse postoperative outcomes of OSAS in hip or knee replacement compared with matched control patients,reported first in 2001
- In a study of 172 elective surgical patients who had OSA,stratification done on basis of no. of oxygen desaturations per hour of at least 4% (ODI4%)

  --pts. with an ODI4% of >5 had higher PPCs(8 vs 1%) comp. with ODI4%<5

Anethesiology 2006; 104:1081

Chest 2008;133:1128

Obes Surg 2009

Pulmonary hypertension

- Pulmonary hypertension (PH) increases complication rates after surgery
- In 145 pts. with PH complications including respiratory failure (41), cardiac dysrhythmia (17), CHF (16), renal insufficiency (10) & sepsis(10) were seen --risk predictors included h/o pulmonary embolus,NYHA functional class ≥2, intermediate or high risk surgery, and duration of anesthesia > 3 hours
- Another study compared 62 patients with PH to matched controls --- mortality (10 % versus 0) and major morbidity (24 versus 3 %) were both significantly higher among patients with pulmonary hypertension

J Am Coll Cardiol 2005; 45:1691

Br J Anaesth 2007;99:184

Heart failure(HF)

- Risk of PPCs may be higher in patients with HF than in those with COPD
- ACP guideline data, showed pooled adjusted OR for PPCs at 2.93 (95% CI 1.02-8.43) for HF pts. and 2.36 (1.90-2.93) for pts. with COPD
- The original Goldman cardiac risk index has been shown to predict postoperative pulmonary as well as cardiac complications
- Though the Revised Cardiac Risk Index is more commonly used to estimate risk for cardiovascular complications, validation studies of the revised index in predicting pulmonary complications have not been done

Ann Intern Med 2006; 144:581

Chest 1996; 110:744

General health status

- Overall health status is an important determinant of pulmonary risk
- Functional dependence and impaired sensorium each increase PPCs
- American Society of Anesthesiologists (ASA) classification correlates well as predictors of pulmonary risk (Tab.A)
- Accounts for systemic disease that affects activity/is a threat to life
- Pre-existing lung disease would be classified in a higher ASA class
- ASA class >2 confers a 4.87 fold increase in risk (95% CI 3.34-7/10)

Arch Intern Med 1992; 152:967

Ann Intern Med 2006; 144:581

ASA class	Physical status	Functional status	Examples	Risk status/Rate of PPCs
1	Healthy , no disease outside surgical process	Can walk up1 flight of stairs /2 level city block without distress Little/no anxeity		Little/no risk *Green flag Tt,* *1.2%*
2	Mild/mod systemic disease, well controlled medically, no functional limitation	Can walk up1 flight of stairs/2 level city blocks , stops with distress after that Extreme fear/anxeity , respiratory condition/pregnancy/active allergy	controlled asthma, Smoker, age>70	Minimal risk *Yellow flag for treatment* *5.4%*
3	Moderately Severe systemic disease with functional limitation	Can walk up1 flight of stairs/2 level city blocks but will have to stop enroute because of distress	COPD, morbid obesity	*Yellow flag for treatment* *11.4%*
4	Severe disease with constant threat to life	Unable to walk up 1 flight of stairs or 2 level city blocks ,ditress at rest	Sev. COPD Advance pulm dysfunction	Risk electiv surg Emg med cx /tt *Red flag tt* *10.9%*
5	Moribund pt dying in 24 hrs without surgical intervention		Pulmonary embolus	Elect tt C/I Em surg +/- Red flag tt
6	Brain death for organ harvest			
E	Emergency Surg for any class	Any pt. in who require emergency operation		

Tab.A.. American Society of Anesthesiologists (ASA) physical status scale (expanded version)

Adapted from JAMA 1988;260:2859

Upper respiratory infection (URI)

- Data about PPCs among adults undergoing high-risk surgical procedures with current or recent upper respiratory infection are limited
- Minor URI without fever or productive cough can undergo elective surgery
- Pts. with fever & productive cough especially with underlying respiratory ds. or thoracic/abdomonal surgery should be treated before surgery

Metabolic factors

- A multifactorial risk index for PPCs identified two metabolic risk factors
  --Albumin less than 3 g/dL (OR 2.53)
  -- blood urea nitrogen (BUN) greater than 30 mg/dL (OR 2.29)
- A systematic review found that a low serum albumin
  --has similar risk of PPCs like the most important patient-related risk factors
  -- has a stronger predictor of risk than an elevated BUN

Ann Surg 2000;232:242
Ann Intern Med 2006; 144:581

Table 1. **Patient-Related Risk Factors for Postoperative Pulmonary Complications***

Risk Factor	Studies, *n*	Pooled Estimate Odds Ratio (95% CI)†	I^2, %†	Trim-and-Fill Estimate Odds Ratio (95% CI)‡
Age				
50–59 y	2	1.50 (1.31–1.71)	0.0	–
60–69 y	7	2.28 (1.86–2.80)	50.4	2.09 (1.65–2.64)
70–79 y	4	3.90 (2.70–5.65)	81.6	3.04 (2.11–4.39)
≥80 y	1	5.63 (4.63–6.85)	–	–
ASA class				
≥II§	6	4.87 (3.34–7.10)	0.0	4.87 (3.34–7.10)
≥III§	11	3.12 (2.17–4.48)	65.2	2.55 (1.73–3.76)
Abnormal chest radiograph	2	4.81 (2.43–9.55)	0.0	–
CHF	3	2.93 (1.02–8.43)	92.1	2.93 (1.02–8.03)
Arrhythmia	1	2.90 (1.10–7.50)	–	–
Functional dependence				
Partial	2	1.65 (1.36–2.01)	82.6	–
Total	2	2.51 (1.99–3.15)	67.9	–
COPD	8	2.36 (1.90–2.93)	82.0	1.79 (1.44–2.22)
Weight loss	2	1.62 (1.17–2.26)	91.7	–
Medical comorbid condition	1	1.48 (1.10–1.97)	–	–
Cigarette use	5	1.40 (1.17–1.68)	67.5	1.26 (1.01–1.56)
Impaired sensorium	2	1.39 (1.08–1.79)	63.0	–
Corticosteroid use	1	1.33 (1.12–1.58)	–	–
Alcohol use	2	1.21 (1.11–1.32)	0.0	–

* ASA = American Society of Anesthesiologists; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease.
† For I^2 definition and values, see the Appendix, available at www.annals.org.
‡ Estimates derived from meta-analysis of adjusted odds ratios from multivariable studies.
§ When compared with patients with lower ASA class values.

Ann Intern Med 2006;144:595–608

PROCEDURE RELATED RISK FACTORS

- Surgical factors that may affect pulmonary risk include the following:
  --Surgical site
  --Duration of surgery
  --Type of anesthesia
  --Type of neuromuscular blockade
  --Type of surgery eg.emergency surgery

Ann Intern Med 2006; 144:575

Surgical site

- It is the most important factor in predicting risk of PPCs-- complications inversely related to distance of incision from diaphragm
- Complication rate significantly higher for thoracic and upper abdominal surgery than for lower abdominal and other procedures
- In a systematic review of 83 studies, complication for upper, lower abdominal surgeries,and esophagectomy were 19.7, 7.7,& 18.9% resp.
- Abdominal aortic aneurysm repair,head and neck surgery and neurosurgery are also associated with a high risk of PPCs
- Laparoscopic cholecystectomy a/w less reduction in postop.lung volume
- But analysis of 12 studies of laparoscopic vs open colon cancer surgery showed no reduction in pulmonary complications(OR 0.65,CI 0.28-1.49)

Acta Anaestheiol Scand 2001; 45:345

Med Clin North Am 2003; 87:7

Ann Intern Med 2006; 144:581

Duration of surgery

- Surgical procedures lasting more than 3 to 4 hrs are associated with a higher risk of pulmonary complications
- A study of risk factors for postoperative pneumonia in 520 patients found an incidence of 8% for surgeries lasting less than 2 hrs vs 40% for procedures lasting more than 4 hrs

Am Rev Respir Dis 1984; 130:12

Acta Anaestheiol Scand 2001; 45:345

Type of anesthesia

- Conflicting data of PPCs in spinal(SA)/epidural vs general anesthesia(GA)
- No difference of PPCs found in pts undergoing transurethral prostate/ abdominal surgery with spinal anesthesia vs GA ,in initial studies
- But retrospective study of 475 men with chronic lung disease undergoing general surgery had a 9% death in GA group vs nil in SA group
- A large systematic review of 141 trials including 9559 patients reported a reduction of 39% of pneumonia and a 59% of respiratory depression among patients receiving neuraxial blockade (epidural/SA).
- Regional nerve block is associated with lower risk and should be considered when possible for high risk patients

JAMA 1988; 260:2859

Chest 1979; 76:123

BMJ 2000; 321:1493

Type of neuromuscular blockade

- Residual neuromuscular blockade is an important risk factor for critical respiratory events in the immediate postoperative period
- A higher incidence of postoperative pulmonary complications in those patients with residual neuromuscular blockade
- Pancuronium ,a long-acting neuromuscular blocker, leads to a higher incidence of postoperative residual neuromuscular blockade than do shorter acting agents

Anaesth Analg 2008; 107:130

Acta Anaesthesiol Scand 1997; 107:130

Table 2. **Procedure-Related Risk Factors for Postoperative Pulmonary Complications**

Risk Factor	Studies, *n*	Pooled Estimate Odds Ratio (95% CI)*	I^2, %†	Trim-and-Fill Estimate Odds Ratio (95% CI)*
Surgical site				
Aortic	2	6.90 (2.74–17.36)	97.30	–
Thoracic	3	4.24 (2.89–6.23)	89.70	4.24 (2.89–6.23)
Any abdominal	6	3.09 (2.54–3.77)	59.50	3.01 (2.43–3.72)
Upper abdominal	4	2.96 (2.40–3.63)	66.40	2.91 (2.35–3.60)
Neurosurgery	2	2.53 (1.84–3.47)	71.00	–
Head and neck	2	2.21 (1.82–2.68)	0.00	–
Vascular	2	2.10 (0.81–5.42)	98.70	–
Emergency surgery	6	2.52 (1.69–3.75)	93.80	2.21 (1.57–3.11)
Prolonged surgery	5	2.26 (1.47–3.47)	67.80	2.26 (1.47–3.47)
General anesthesia	6	2.35 (1.77–3.12)	81.70	1.83 (1.35–2.46)
Transfusion (>4 units)	2	1.47 (1.26–1.71)	0.00	–

* Estimates derived from meta-analysis of adjusted odds ratios from multivariable studies.
† For I^2 definition and values, see the Appendix, available at www.annals.org.

Ann Intern Med 2006;144:595–608

Laboratory tests

- Laboratory tests that may be needed are:
  --Pulmonary function tests (PFTs)
  --Arterial blood gas (ABG)analysis
  --Chest radiographs (CXR)
  --Exercise testing

Pulmonary function testing

- These tests confirm the clinical impression of disease severity , but add little to estimation of risk–so are overused & wasted health resources
- Early reviews suggested criteria for increased risk that included :
  --FEV1 <70 percent predicted
  --FVC <70 percent predicted
  --FEV1/FVC ratio <65 percent
- Two reasonable goals that could justify the use of preoperative PFTs:
  --Identification of pts. for whom risk of surgery is not justified by benefit
  --Identification of a subset of pts at higher risk for whom aggressive perioperative management is warranted
- These goals are usually not met in non-thoracic surgery

- In COPD (FEV1 <50% predicted), preoperative PFTs did not predict PPCs but length of surgery, ASA class,& procedure were significant predictors
- In 164 pts.of abd.surgery,no component of spirometry predicted PPCs
- A critical review of preoperative PFT found its values to be significant risk predictors in 3 of 4 studies that used multivariable analysis

  --but other factors like ASA class >3 & chronic mucous hypersecretion conferred higher OR for PPCs than abnormal spirometry in 2 of these
- A case control study found no difference in FEV1, FVC, or FEV1/FVC between pts who had/had'nt PPCs in abdominal surgery

  --but factors from the physical examination did predict risk
- 2nd study,obstruction (FEV1 ≤ 40% predicted) compared with normal FEV1 --only bronchospasm was commoner in pts with abnormal spirometry

Chest 1997; 111:564

Resp Med 2000; 94:1171

Anesthesiology 1999; 90:372

Arterial blood gas analysis

- No data identify hypercapnia (without clinical risk factor) as high-risk pts
- Small case series suggested risk of PPCs in pts. with a $PaCO_2$ >45 mmHg, a finding seen only in pts. with severe chronic obstructive lung ds.
- One study reported association between preoperative hypoxemia and PPCs among 102 pts. undergoing surgery for gastric cancer
- But hypoxemia is generally not identified as a significant independent predictor of complications after adjustment for potential confounders
- Current data do not support the use of preoperative arterial blood gas analyses to stratify risk for postoperative pulmonary complications

Br J Surg 1987; 74:408

Chest radiographs (CXR)

- Prevalence of abnormal preoperative CXR increases with age
- CXR add little to identify healthy pts. at risk for PPCs
- One study screened 905 surgical admissions for presence of clinical factors thought to be risk factors for abnormal preoperative CXR,

  eg.age >60 yrs or findings consistent with cardiac /pulmonary disease

  --no risk factor was evident in 368 patients--only 1(0.35%) had an abnormal CXR, which did not affect the surgery

  -- 504 patients had identifiable risk factors--114 (22 %) had significant abnormalities on preoperative CXR
- A meta-analysis of preoperative CXR showed low utility yield for mgmnt.
  --14,390 preop.CXR--140 abn. seen,only 14 cases influenced management

JAMA 1983; 250:3209
Can J Anaesth 1993; 40:1022

Exercise testing

- Exercise testing studied extensively in for lung resection surgery
- Cardiopulmonary exercise testing (CPET) with calculation of maxm. oxygen intake and ventilatory anaerobic threshold may have a role in unexplained dyspnea after clinical evaluation undergoing noncardiopulmonary surgery

  ---In a systematic review, most of 9 eligible studies found that both measurements predicted survival & overall complications ,though the studies did not measure PPCs as a separate outcome

Anaesthesia 2009; 64:883

Ann Intern Med
2006;144:595–608

Table 3. **Summary Strength of the Evidence for the Association of Patient, Procedure, and Laboratory Factors with Postoperative Pulmonary Complications***

Factor	Strength of Recommendation†	Odds Ratio‡
Potential patient-related risk factor		
Advanced age	A	2.09–3.04
ASA class ≥ II	A	2.55–4.87
CHF	A	2.93
Functionally dependent	A	1.65–2.51
COPD	A	1.79
Weight loss	B	1.62
Impaired sensorium	B	1.39
Cigarette use	B	1.26
Alcohol use	B	1.21
Abnormal findings on chest examination	B	NA
Diabetes	C	
Obesity	D	
Asthma	D	
Obstructive sleep apnea	I	
Corticosteroid use	I	
HIV infection	I	
Arrhythmia	I	
Poor exercise capacity	I	
Potential procedure-related risk factor		
Aortic aneurysm repair	A	6.90
Thoracic surgery	A	4.24
Abdominal surgery	A	3.01
Upper abdominal surgery	A	2.91
Neurosurgery	A	2.53
Prolonged surgery	A	2.26
Head and neck surgery	A	2.21
Emergency surgery	A	2.21
Vascular surgery	A	2.10
General anesthesia	A	1.83
Perioperative transfusion	B	1.47
Hip surgery	D	
Gynecologic or urologic surgery	D	
Esophageal surgery	I	
Laboratory tests		
Albumin level < 35 g/L	A	2.53
Chest radiography	B	4.81
BUN level > 7.5 mmol/L (>21 mg/dL)	B	NA
Spirometry	I	

* ASA = American Society of Anesthesiologists; BUN = blood urea nitrogen; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; NA = not available.
† Recommendations: A = good evidence to support the particular risk factor or laboratory predictor; B = at least fair evidence to support the particular risk factor or laboratory predictor; C = at least fair evidence to suggest that the particular factor is not a risk factor or that the laboratory test does not predict risk; D = good evidence to suggest that the particular factor is not a risk factor or that the laboratory test does not predict risk; I = insufficient evidence to determine whether the factor increases risk or whether the laboratory test predicts risk, and evidence is lacking, is of poor quality, or is conflicting. From reference 12.
‡ For factors with A or B ratings. Odds ratios are trim-and-fill estimates. When these estimates were not possible, we provide the pooled estimate.

Table 2
ACP 2006 guideline: strength of the evidence for specific interventions to reduce the risk of PPCs

Risk Reduction Strategy	Strength of Evidence[a]	Type of Complication Studied
Postoperative lung expansion modalities	A	Atelectasis, pneumonia, bronchitis, severe hypoxemia
Selective postoperative nasogastric decompression	B	Atelectasis, pneumonia, aspiration
Short-acting neuromuscular blockade	B	Atelectasis, pneumonia
Laparoscopic (versus open) operation	C	Atelectasis, pneumonia, respiratory failure
Smoking cessation	I	Postoperative ventilator support
Intraoperative neuraxial blockade	I	Pneumonia, postoperative hypoxia, respiratory failure
Postoperative epidural analgesia	I	Atelectasis, pneumonia, respiratory failure
Immunonutrition	I	Overall infectious complications, pneumonia, respiratory failure
Routine total parenteral or enteral nutrition[b]	D	Atelectasis, pneumonia, empyema, respiratory failure
Right heart catheterization	D	Pneumonia

[a] Definitions: A, there is good evidence that the strategy reduces PPC and benefit outweighs harm; B, there is at least fair evidence that the strategy reduces PPC and benefit outweighs harm; C, there is at least fair evidence that the strategy may reduce PPC but the balance between benefit and harm is too close to justify a general recommendation; D, there is at least fair evidence that the strategy does not reduce PPC or harm outweighs benefit; I, evidence of effectiveness of the strategy to reduce PPC is conflicting, of poor quality, lacking, insufficient, or the balance between benefit and harm can not be determined.

[b] The evidence remains uncertain (I) regarding total parenteral or enteral nutrition for the severely malnourished or when a protracted time of inadequate nutritional intake is anticipated.

Ann Intern Med 2006;144:595–608

PULMONARY RISK INDICE

- Cardiac risk indices since ‘77 stratify perioperative cardiac complications
- No index developed for risk stratification of pulmonary complications
- Three studies have proposed pulmonary risk indices:
  1. Cardiopulmonary risk index (CPRI)
  2. Brooks-Brunn risk index
  3. Multifactorial risk index for postoperative respiratory failure

1. Cardiopulmonary risk index (CPRI)

pulmonary risk factors added in pts.of pulmonary resection upon Goldman criteria for cardiac risk include:

--Obesity (BMI >27 kg/m2)

--Cigarette smoking within eight weeks of surgery

--Productive cough within five days of surgery

--Diffuse wheezing or rhonchi within five days of surgery

--FEV1/FVC <70 percent, and PaCO2 >45 mmHg

- In a trial of 43 pts. undergoing thoracic and upper abdominal surgery, 8 with a CPRI >3 (of 10 possible points) experienced pulmonary complications

Am J Crit Care Med 1995; 151:A292

2.Brooks-Brunn risk index

- Study of 400 pts. undergoing abdominal surgery identified risk criteria , 6 factors independently a/ w increased PPCs in abdominal surgery:

  --Age >60

  --Obesity (BMI >27 kg/m2)

  --Impaired cognitive function

  --History of cancer

  --Smoking history in past eight weeks

  --Upper abdominal incision

- In a subsequent validation cohort , the original model validated well, but when a new model was developed different factors (abd incision location,incision length,h/o angina,ASA status 3,4,5)emerged as significant

Chest 1997; 111:564

3.Multifactorial risk index for postoperative respiratory failure(Tab.B)

- The index modeled after cardiac risk indices using a prospective cohort model from a large Veterans Administration database
- Factors predicting postop.respiratory failure evaluated,assigning points to each,based on strength in multivariate analysis,and developed a risk score
- Procedure-related factors---type,emergency surg. are important predictors
- Importance of abdominal aortic aneurysm repair, emergency surgery, and metabolic factors as risk factors,emphasised
- Same group reported a simple index to predict postoperative pneumonia,but is limited in utility as most factors are not modifiable
- An updated complex respiratory failure index from non-Veterans Administration private sector academic institutions was also not suited for clinical practice except as a tool for future

Ann Surg 2000; 232:242

Tab.B

Arozullah multifactorial risk index for predicting postoperative respiratory failure

Variable	Odds ratio (95% CI)	Point value
Type of surgery		
Abdominal aortic aneurysm	14.3 (12.0–16.9)	27
Thoracic	8.14 (7.17–9.25)	21
Neurosurgery, upper abdominal, or peripheral vascular	4.21 (3.80–467)	14
Neck	3.10 (2.40–4.01)	11
Emergency surgery	3.12 (2.83–3.43)	11
Albumin <3.0 gm/dL	2.53 (2.28–2.80)	9
Blood urea nitrogen >30 mg/dL	2.29 (2.04–2.56)	8
Partial or fully dependent functional status	1.92 (1.74–2.11)	7
History of COPD	1.81 (1.66–1.98)	6
Age (y) >69	1.91 (1.71–2.13)	6
60–69	1.51 (1.26–1.69)	4

Class	Point total	Postoperative pulmonary complication rates (validation cohort)
1	<11	0.5%
2	11–19	1.8%
3	20–27	4.2%
4	28–40	10.1%
5	>40	26.6%

Adapted from Arozullah AM, Daley J, Henderson WG, et al. Multifactorial risk index for predicting postoperative respiratory failure in men after major noncardiac surgery. Ann Surg 2000;232:242–53.

Special situations

- Elderly:
  -- study of 7,306 anesthetics in pts. >80 years of age,10.2% developed PPCs similar to 7% found in another study of similar age

  -- prior h/o CHF & neurologic ds. increase PPCs by multivariate analysis

  -- optimization of respiratory function is important in decreasing PPCs

  --smoking cessation a/w better outcomes even immediately prior to surg.
  -- patients unable to raise heart rate >99 bpm or perform 2 mts. of supine bicycle exercise had more cardiopulmonary complication (42% vs 9.3%)

Acta Am J Med. 1990; 88:101-107

Anaesthesiol Scand. 1990;34:144-55

J Am Geriatr Soc. 2000; 48:405-412

Special situations..

- Healthy patients:

  -- routine lab. tests has poor predictive value with false +ve results &/or increased medicolegal risk for not following up abnormal test results

  -- simple screening questionnaire helpful in preoperative evaluation

  --risks include age,exercise capacity,alcohol,smoking,& medication use

  --obesity is not a risk for most PPCs in noncardiac surgery

  -- hemoglobin measurement for >65 yrs of age undergoing major surgery and for younger patients with expected significant blood loss

  -- pregnancy test in reproductive age women better than history alone

  --no routine PFT, or CXR except in cardiopulmonary disease & >50 yrs of age undergoing abdominal aortic aneurysm or upper abdominal surgery

Anesth Analg 2009; 108:467

Strategies to reduce postoperative pulmonary complications

Preoperative:

- Smoking cessation as early as possible; cessation >8 wks of greater benefit
- Inhaled ipratropium or tiotropium for all with clinically significant COPD
- Inhaled beta-agonists for pts. with COPD or asthma with wheeze/dyspnea
- Glucocorticoids (syst./ICS) for patients with COPD or asthma who are not optimized /whose airway obstruction has not been maximally reduced
- Delay elective surgery if respiratory infection(fever/expectoraton) present
- Antibiotics for patients with infected sputum
- Patient education (lung expansion maneuvers such as coughing, incentive spirometry, and voluntary deep breaths) & inspiratory muscle training

Strategies to reduce postoperative pulmonary complications…

Intraoperative :

- Choose procedure lasting less than three to four hours if possible
- Minimize duration of anesthesia
- Surgery other than upper abdominal or thoracic when possible
- Regional anesthesia (nerve block) in very high-risk patients
- Avoid pancuronium as a muscle relaxant in high-risk patients
- Choosing laparoscopic over open abdominal surgery may be beneficial
- Epidural or spinal anesthesia may confer lower risk than GA
- Perioperative pulmonary artery catheterization is not beneficial

Strategies to reduce postoperative pulmonary complications…

Postoperative:

- Deep breathing exercises or incentive spirometry in high risk patients
- Epidural analgesia in place of parenteral opioids
- Probably beneficial postoperative interventions:

  --continuous positive airway pressure (CPAP)

  --intercostal nerve blocks

  --nasogastric tubes (for symptoms only) after abdominal surgery

Perioperative management of pulmonary agents

Name/ class of drug	Clinical consideration	Strategy for surgery with brief NPO state	Strategy for surgery with prolonged NPO state
Inhaled bronchodilators (beta agonists and anticholinergics)	No known adverse effects	Continue therapy up to and including day of surgery	Continue therapy up to and including day of surgery. Use nebulized forms if patient unable to comply with inhalation maneuver
Theophylline	No known adverse effects but narrow therapeutic index	Continue up to day before surgery. Discontinue the evening before surgery	Continue up to day before surgery Discontinue evening before surg. Resume with PO intake. Use nebulized or inhaled beta agonist or anticholinergics
Leukotriene inhibitors	No known adverse effects	Continue therapy up to and including day of surgery	Continue therapy up to and including day of surgery and resume when patient able to take oral medications
Corticosteroids	If withdrawn abruptly,adrenal insufficiency,in stress of surgery	Continue systemic glucocorticoids & ICS perioperative period, +/-stress dosing	Continue systemic glucocorticoids & ICS in perioperative period,+/- stress dosing

Prevention of venous thromboembolic disease in surgical patients

- If contraindicated to anticoagulant thromboprophylaxis,mechanical (intermittent pneumatic/graduated compression stockings and venous foot pump) methods of thromboprophylaxis advisable
- Pharmacologic agent (eg, LMW heparin) as soon as permissible
- Early & frequent ambulation for low risk surgery with minor procedures
- Anticoagulation in higher risk surgery with major/complicated procedure
- In multiple VTE risk, pharmacologic with optimal mechanical method
- For bariatric surgery higher doses of LMW heparin or low dose unfractionated heparin than usual for nonobese patients be employed
- For major surgery, thromboprophylaxis continued until hospital discharge
- For higher risk pts (cancer or prior VTE) LMWH considered up to 28 days

Ann Surg 2010; 251:393

(ENDORSE study)Lancet 2008; 371:387

General principles of medical consultation

- Verbal communication with requesting team prevents misinterpretation
- To "clear“may imply that procedure carries no risk for patient;if no risks are present better statement is ‘’average risk’’ for the proposed procedure
- Whether surgery to proceed or not is not directly told to pts.but estimate of the risk of perioperative medical complications may be communicated
- No. of recommendations should be limited to five or fewer
- The consultant should respond in a timely fashion (< 24 hours)
- Medications should specify drug name, dose, frequency, route of administration, and duration, alternatives therapy if any
- When no more follow up is needed,consultant should sign off the case

STEPWISE PREOPERATIVE RISK ASSESSMENT

- History & physical examination (PE) --most important to identify risks
- History suggesting chronic lung disease or heart failure,eg. exercise intolerance, unexplained dyspnea, or cough, requires consideration
- Reasonable to ask obese pts for symptoms of OSA in a major surgery
- PE directed towards obstructive lung disease, noting decreased breath sounds, wheezes, rhonchi, or prolonged expiratory phase
- Lab. Tests (PFT,ABG,CXR,Exercise Test) obtained in selected patients
- Arozullah index(Tab.B)--promising tool for risk assessment--high risk pts. will benefit from aggressive strategies to reduce pulmonary complications

- CXR in high risk surgery >50 yrs of age, or if cardiopulmonary disease suggested by clinical evaluation, unless one was done in past six months
- PFT only with uncharacterized dyspnea,exercise intolerance,COPD/asthma with clinical uncertainty if airflow obstruction is optimally reduced or not

  ----benefit of PFTs in other situations is unproved
- No role for preoperative ABG to identify high risk patients/to deny surgery

Summary of risk factors for PPCs

Definite risk factors include the following:

- Age >50 years
- Chronic obstructive lung disease
- Congestive heart failure
- Poor general health status as defined by ASA class >2
- Functional dependence
- Serum albumin <35 gm/L
- Upper abdominal, thoracic, aortic, head and neck, neurosurgery, and abdominal aortic aneurysm surgery
- Surgery lasting greater than three hours
- Emergency surgery
- Use of pancuronium as a neuromuscular blocker

Summary of risk factors for PPCs..

Probable risk factors include the following:

- Obstructive sleep apnea
- General anesthesia (compared with spinal or epidural anesthesia)
- $PaCO_2$ >45 mmHg
- Abnormal chest radiograph
- Cigarette use within the previous eight weeks
- Ongoing upper respiratory tract infection

Message for preoperative assessment for reducing PPCs

- *Should be evaluated in: COAD, >60 yrs,ASA≥II, functionally dependent,CHF*
- *Not significant risk for PPCs in: obesity,mild or moderate asthma*
- *At higher risk for PPCs,evaluate for other concomitant risk factors in: prolonged (>3 hours), abdominal , thoracic , neuro, head and neck , vascular , aortic aneurysm repair, emergency surgeries, and GA*
- *Ser. albumin level (<35 g/L) is marker of risk of PPCs & should be measured in suspected cases of hypoalbuminemia or has ≥1 risk factors for PPCs*
- *Pts. at high risk for PPCs should receive the following POP procedures :*

  1) deep breathing exercises or incentive spirometry

  2) selective use of NG tube (postoperative nausea or vomiting , inability to tolerate oral intake, or symptomatic abdominal distention)
- *PFT and CXR not used routinely except in pts with h/o of COAD or asthma*
- *No role for ABG analyses to identify high risk patients or to deny surgery*