

Citywide Resident Perioperative Medical Consult Conference

## Perioperative Pulmonary Management

Frank Jacono, MD  
May 5, 2017



## Objectives

- Definition of post-operative pulmonary complications (PPC)
- Risk factors for increased PPC:
  - Patient-Related
  - Surgery-Related
- Strategies to reduce PPC:
  - Pre-op
  - Peri-op
  - Post-op

## Postoperative Pulmonary Complications

- *“A pulmonary abnormality that produces identifiable disease or dysfunction that is clinically significant and adversely affects the clinical course”*
- PPC include:
  - Atelectasis
  - Infection, including bronchitis and pneumonia
  - Prolonged mechanical ventilation and respiratory failure
  - Exacerbation of underlying chronic lung disease
  - Bronchospasm

## Postoperative Pulmonary Complications

- The frequency of PPC varies from 2-70%
- This wide range is due to:
  - Patient selection
  - Procedure-related risk factors
  - Different definitions \*\*\*
- Nearly 25% of deaths occurring within 6 days postoperatively are related to PPC

## Perioperative Pulmonary Physiology

- Thoracic and Upper abdominal surgeries:
  - Diaphragmatic dysfunction → Pain and splinting:
    - VC ↓ 50-60% → 1 week
    - FRC ↓ 30%
  - TV ↓, Loss of sighing breaths, Increased RR
  - Depress respiratory drive:
    - Residual effect of anesthesia and Post-op opioids
- Lower Abdominal Surgery:
  - Same effects (but not as dramatic)
- Extremities Surgery:
  - No effect on lung volumes

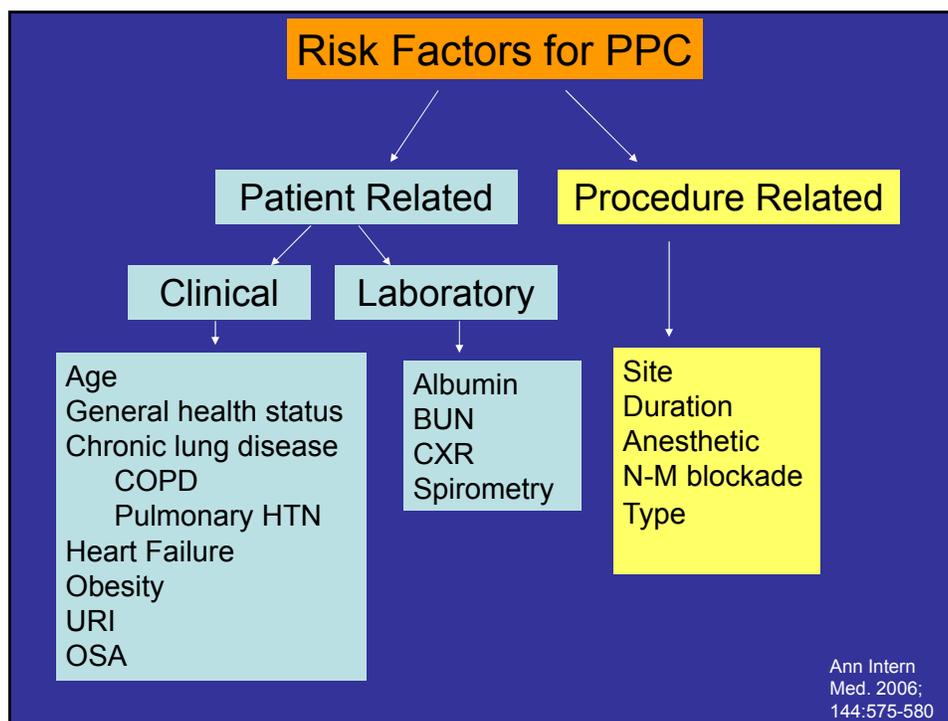
Annals of Internal Medicine

CLINICAL GUIDELINES

### Risk Assessment for and Strategies To Reduce Perioperative Pulmonary Complications for Patients Undergoing Noncardiothoracic Surgery: A Guideline from the American College of Physicians

Amir Qaseem, MD, PhD, MHA; Vincenza Snow, MD; Nick Fitterman, MD; E. Rodney Hombake, MD; Valerie A. Lawrence, MD; Gerald W. Smetana, MD; Kevin Weiss, MD, MPH; and Douglas K. Owens, MD, MS, for the Clinical Efficacy Assessment Subcommittee of the American College of Physicians\*

Ann Intern Med. 2006; 144:575-580



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

Risk Factor	Studies, n	Pooled Estimate Odds Ratio (95% CI)†	P, %‡	Trim-and-Fill Estimate Odds Ratio (95% CI)‡
<b>Age</b>				
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)	-	-
<b>ASA class</b>				
≥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)	-	-
<b>Functional dependence</b>				
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<sup>2</sup> definition and values, see the Appendix, available at [www.annals.org](http://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; 144:575-580

Patient-Related Risk Factors Non Cardio-Thoracic Surgeries	OR
Age (60-69)	2.09 (1.65-2.64)
(70-79)	3.04 (2.11-4.39)
CLD (COPD)	1.79 (1.44-2.22)
Tobacco	1.26 (1.01-1.56)
CHF	2.93 (1.02-8.03)
Functional dependence	
Total	2.51 (1.99-3.51)
Partial	1.65 (1.36-2.01)
ASA ( $\geq$ II)	4.87 (3.34-7.10)
Obesity (BMI>25)	-
Asthma	-
OSA	Trend $\rightarrow$ Yes
Impaired sensorium, abn. Chest exam, ETOH, Weight loss	Modest increase
Exercise capacity, DM, HIV	-

Ann Intern  
Med. 2006;  
144:575-580

## Tobacco Use

- Current cigarette smokers have an increased risk for PPC even in the absence of chronic lung disease
- Smokers with a greater than 20 pack/year smoking history have a higher incidence of PPC than those with less

## Upper Respiratory Tract Infection

- Delay surgery if possible (\*\*\*)
- Prophylactic antibiotics are not helpful

**Obesity and mild or moderate asthma** are **not significant risk factors** for post-operative pulmonary complications after noncardiothoracic surgery

**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‡
<b>Laboratory tests</b>		
Albumin level < 35 g/L ( <b>3.5 g/dL</b> )	A	2.53
Chest radiography	B	4.81
BUN level > 7.5 mmol/L (>21 mg/dL)	B	NA
Spirometry	I	

Ann Intern Med, 2006

## Pulmonary Function Testing

- **Spirometry**
  - Value before extrathoracic surgery remains unproven
  - There is no prohibitive spirometric threshold below which the risks of surgery are unacceptable
  - *Should be reserved for patients who:*
    - *May not be at baseline and require more aggressive optimization*
    - *Unexplained dyspnea or other symptoms*

## Radiographic Testing

- **CXR**
  - 23.1% of pre-op CXR were abnormal
  - Only 3% had findings clinically important enough to influence management
  - 10% of pre-op CXR were abnormal
  - Only 1.3% showed unexpected abnormalities and only 0.1% influenced management
- May be of benefit if:
  - Known cardiopulmonary disease
  - Age > 50
  - Upper abdominal, thoracic, or abdominal aortic aneurysm surgery

Smetana GW, 2002  
Archer C, 1993

## Procedure Related Risk Factors

- **Surgical Site & Technique**
  - Most important factor in predicting the overall risk
  - Incidence of complications is inversely related to the distance of the surgical incision from the diaphragm
  - Laparoscopic procedures better than open procedures
- **Duration of Surgery**
  - 3 to 4 hours (OR: 2.14)
- **Anesthetic Technique**
  - General anesthesia (OR:1.83)
- **Type of NM blockade**
  - Pancuronium (long acting)
- **Emergency Surgery**
  - OR: 2.21

## Surgical Site

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

Risk Factor	Studies, <i>n</i>	Pooled Estimate Odds Ratio (95% CI)*
Surgical site		
Aortic	2	6.90 (2.74–17.36)
Thoracic	3	4.24 (2.89–6.23)
Any abdominal	6	3.09 (2.54–3.77)
Upper abdominal	4	2.96 (2.40–3.63)
Neurosurgery	2	2.53 (1.84–3.47)
Head and neck	2	2.21 (1.82–2.68)
Vascular	2	2.10 (0.81–5.42)
Emergency surgery	6	2.52 (1.69–3.75)
Prolonged surgery	5	2.26 (1.47–3.47)
General anesthesia	6	2.35 (1.77–3.12)
Transfusion (>4 units)	2	1.47 (1.26–1.71)

\* 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](http://www.annals.org).

Ann Intern Med, 2006

## Preoperative Risk Assessment

- History & Physical Exam
  - Target known risk factors
  - Cough, dyspnea, exercise intolerance
  - Sleep apnea

## Assessment of Postoperative Pulmonary Risk

- Risk prediction tools have utility in stratifying risk
- Questionable utility in individual patients
- May identify candidates for preoperative risk reduction interventions or additional testing
- Several tools
  - Gupta calculator for postoperative respiratory failure and pneumonia
  - Download online for free

<b>Table. American Society of Anesthesiologists Classification *</b>			
<b>ASA Class</b>	<b>Class Definition</b>	<b>Rates of PPCs by Class, %</b>	<b>Mortality</b>
I	A normally healthy patient	1.2	<0.03%
II	A patient with mild systemic disease	5.4	0.2%
III	A patient with systemic disease that is not incapacitating	11.4	1.2%
IV	A patient with an incapacitating systemic disease that is a constant threat to life	10.9	8%
V	A moribund patient who is not expected to survive for 24 hours with or without operation	NA	34%

\* Information is from reference 9. ASA = American Society of Anesthesiologists; NA = not applicable; PPC = postoperative pulmonary complication.

Ann Intern Med, 2006

<b>Arozullah respiratory failure index</b>		
<b>Preoperative predictor</b>		<b>Point value</b>
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 chronic obstructive pulmonary disease		6
Age		
>70 years		6
60 to 69 years		4
<b>Class</b>	<b>Point total</b>	<b>Percent respiratory failure</b>
1	≤10	0.5
2	11 to 19	1.8
3	20 to 27	4.2
4	28 to 40	10.1
5	>40	26.6

From Arozullah, AM, Daley, J, Henderson, WG, Khuri, SF, Ann Surg 2000; 232:242.

Uptodate.com

**ARISCAT (Canet) risk index: Independent predictors of postoperative pulmonary complications**

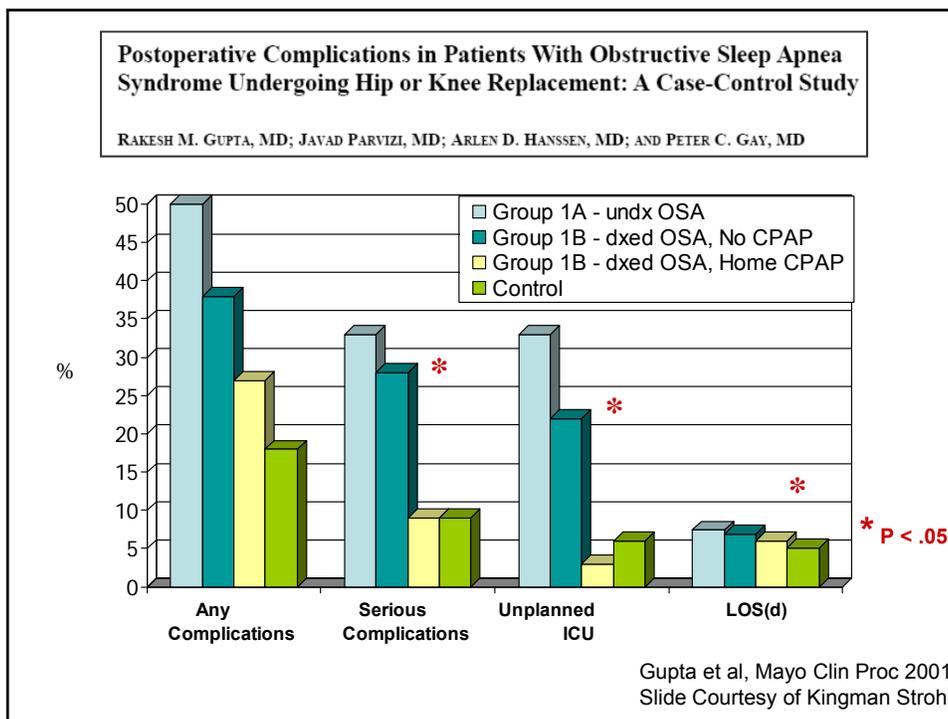
Factor	Adjusted odds ratio (95% CI)	Risk score
<b>Age, years</b>		
≤50	1	
51-80	1.4 (0.6-3.3)	3
>80	5.1 (1.9-13.3)	16
<b>Preoperative O<sub>2</sub> saturation</b>		
≥96 percent	1	
91-95 percent	2.2 (1.2-4.2)	8
≤90 percent	10.7 (4.1-28.1)	24
Respiratory infection in the last month	5.5 (2.6-11.5)	17
Preoperative anemia - hemoglobin ≤10 g/dL	3.0 (1.4-6.5)	11
<b>Surgical incision</b>		
Upper abdominal	4.4 (2.3-8.5)	15
Intrathoracic	11.4 (1.9-26.0)	24
<b>Duration of surgery</b>		
≤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
<b>Risk class</b>	<b>Number of points in risk score</b>	<b>Pulmonary complication rate (validation sample)</b>
Low	<26 points	1.6 percent
Intermediate	26-44 points	13.3 percent
High risk	≥45 points	42.1 percent

Adapted with permission from: Canet J, Gallart L, Gomar C, et al. Prediction of postoperative pulmonary complications in a population-based surgical cohort. *Anesthesiology* 2010; 113:1338.

UpToDate

Uptodate.com

## Obstructive Sleep Apnea



#### STOP-Bang questionnaire

<input type="checkbox"/>	<input type="checkbox"/>	<b>Snoring?</b> Do you <b>Snore Loudly</b> (loud enough to be heard through closed doors or your bed-partner elbows you for snoring at night)?
<input type="checkbox"/>	<input type="checkbox"/>	<b>Tired?</b> Do you often feel <b>Tired, Fatigued, or Sleepy</b> during the daytime (such as falling asleep during driving)?
<input type="checkbox"/>	<input type="checkbox"/>	<b>Observed?</b> Has anyone <b>Observed</b> you <b>Stop Breathing</b> or <b>Choking/Gasping</b> during your sleep?
<input type="checkbox"/>	<input type="checkbox"/>	<b>Pressure?</b> Do you have or are being treated for <b>High Blood Pressure</b> ?
<input type="checkbox"/>	<input type="checkbox"/>	<b>Body Mass Index more than 35 kg/m<sup>2</sup>?</b>
<input type="checkbox"/>	<input type="checkbox"/>	<b>Age older than 50 year old?</b>
<input type="checkbox"/>	<input type="checkbox"/>	<b>Neck size large? (Measured around Adams apple)</b> For male, is your shirt collar 17 inches or larger? For female, is your shirt collar 16 inches or larger?
<input type="checkbox"/>	<input type="checkbox"/>	<b>Gender = Male?</b>
<b>Scoring criteria*:</b>		
<b>For general population</b>		
<b>Low risk of OSA:</b> Yes to 0 to 2 questions		
<b>Intermediate risk of OSA:</b> Yes to 3 to 4 questions		
<b>High risk of OSA:</b> Yes to 5 to 8 questions		

\* For validated scoring criteria in obese patients, please refer to UpToDate topic on surgical risk and the preoperative evaluation and management of adults with obstructive sleep apnea.

**References:**

- Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. *Anesthesiology* 2008; 108:812.
- Chung F, Subramanyam R, Liao P, et al. High STOP-Bang score indicates a high probability of obstructive sleep apnoea. *Br J Anaesth* 2012; 108:768.

## Obstructive Sleep Apnea

- If preoperative evaluation suggests OSA:
  - Manage the patient perioperatively based on clinical criteria alone
  - Obtain sleep studies, and treat in advance of surgery
  - Delay surgery if elective?
- Inpatient versus Outpatient Surgery
  - Patient age, sleep apnea status
  - Coexisting diseases, nature of surgery, type of anesthesia
  - Need for postoperative opioids, adequacy of post-discharge observation,
  - Capabilities of the outpatient facility

Anesthesiology  
2014  
V 120 • No 2

## Obstructive Sleep Apnea

- Postoperative Management
  - Nonsupine positions when possible
  - PCA pumps: avoid continuous background infusions
  - NSAIDS and other modalities (e.g., ice, transcutaneous electrical nerve stimulation) should be considered if appropriate
  - When feasible (unless contraindicated) CPAP or noninvasive positive pressure ventilation (with or without supplemental oxygen) should be continuously administered to patients who were using these modalities preoperatively
  - Have patients bring their own equipment to the hospital.

Anesthesiology  
2014  
V 120 • No 2

## Obstructive Sleep Apnea

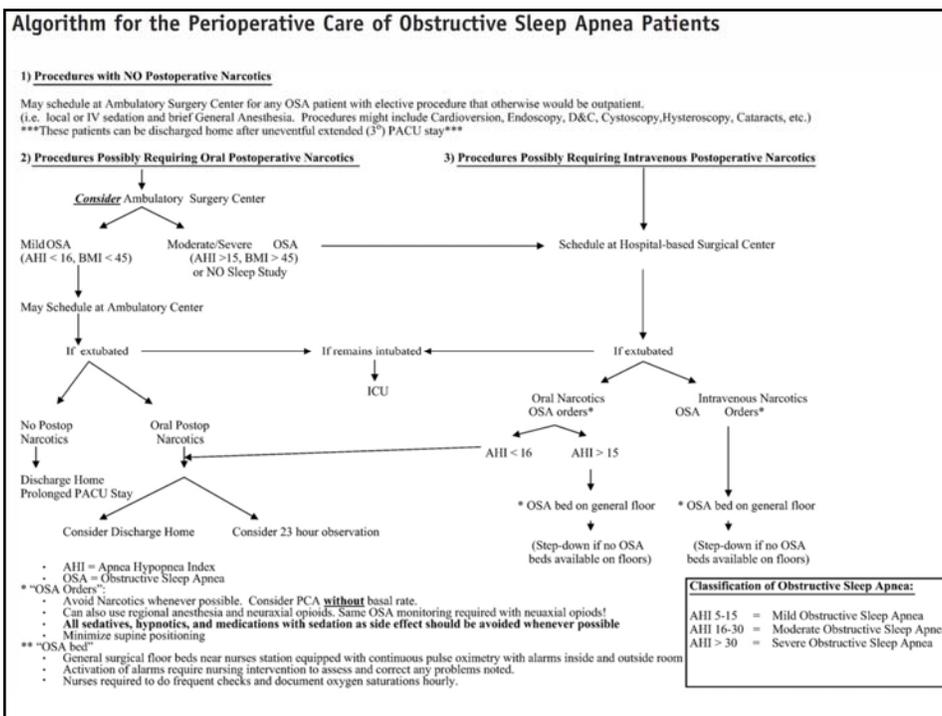
- Postoperative Management
  - Supplemental oxygen should be administered continuously to all patients who are at increased perioperative risk from OSA until they are able to maintain their baseline oxygen saturation while breathing room air
  - However, supplemental oxygen may increase the duration of apneic episodes and may hinder detection of atelectasis, transient apnea, and hypoventilation by pulse oximetry
  - Hospitalized patients who are at increased risk of respiratory compromise from OSA should have continuous pulse oximetry monitoring after discharge from the recovery room
  - Continuous monitoring should be maintained as long as patients remain at increased risk

Anesthesiology  
2014  
V 120 • No 2

## Obstructive Sleep Apnea

- Criteria for Discharge to Unmonitored Settings
  - Patients at increased perioperative risk from OSA should not be discharged from the recovery area to an unmonitored setting (i.e., home or unmonitored hospital bed) until they are no longer at risk of postoperative respiratory depression.
  - This may require a longer stay as compared with non-OSA patients undergoing similar procedures
  - To establish that patients are able to maintain adequate oxygen saturation levels while breathing room air, respiratory function may be determined by observing patients in an unstimulated environment, preferably while asleep

Anesthesiology  
2014  
V 120 • No 2



## Strategies to Reduce the Risk of PPC

- Pre-operative
- Intra-operative
- Post-operative

## Preoperative

- **Beneficial strategies:**
  - Smoking cessation for  $\geq 8$  weeks
  - Inhaled ipratropium or tiotropium for all patients with clinically significant COPD
  - Inhaled beta-agonists for patients with COPD or asthma who wheeze or have dyspnea
  - Preoperative corticosteroids for patients with COPD or asthma who are not optimized to best baseline and whose airway obstruction has not been maximally reduced
  - Delay elective surgery if respiratory infection present
  - Antibiotics for patients with infected sputum
  - Patient education regarding lung expansion maneuvers

## Preoperative

- **Preoperative Smoking Cessation**
  - Only one RCT of a preoperative smoking cessation intervention: 6 to 8 weeks before  $\rightarrow$  10 days after hip or knee surgery
  - Results:
    - Overall complication rates was lower in the intervention group
      - Less wound complications and urinary infections
      - Trend toward shorter hospital stay and cardiac complications
    - *Postoperative ventilatory support* was the only measured pulmonary outcome and occurred in 1 patient in each group

Møller AM et al 2002

## Preoperative

- **Preoperative Smoking Cessation**

- A cohort study showed paradoxically higher PPC rates for smokers who stopped or reduced smoking within 2 months before non-cardiothoracic surgery
- A prospective study of 200 patients undergoing CABG:
  - Tobacco cessation  $\leq 2$  months vs.  $\geq 2$  months:
    - PPC rate: 57.1 versus 14.5 %
  - Tobacco cessation  $\geq 6$  months vs. never smoked:
    - PPC rate: 11.1 and 11.9 %

Warner MA, 1989  
Bluman LG, 1998

## Intraoperative Care

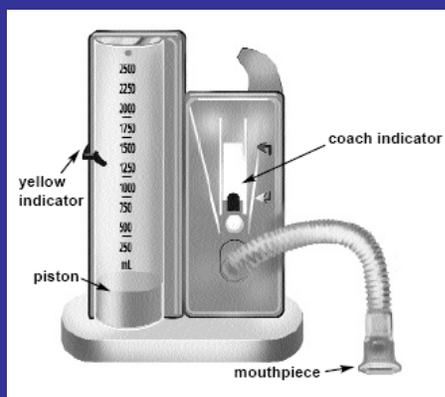
- **Pulmonary Artery Catheter**
  - One RCT of patients ASA class III and VI:
    - No difference in mortality or post-op pneumonia
  - No beneficial effect of PAC strategy to reduce PPC
- **Anesthesia**
  - Data is insufficient
- **NM blockade**
  - Avoid long acting like pancuronium
- **Techniques**
  - Lap vs. open

## Post-operative

- Lung Expansion Modalities
  - Incentive spirometry
  - Chest physical therapy, including deep breathing exercises
  - Cough
  - Postural drainage
  - Percussion and vibration
  - Suctioning and ambulation
  - Intermittent positive-pressure breathing and continuous positive-airway pressure

## Post-operative

- For patients undergoing abdominal surgery, any type of lung expansion intervention is better than no prophylaxis at all
- No one modality is clearly superior
- Combined methods do not give additional benefit
- Incentive Spirometry is the least labor -intensive

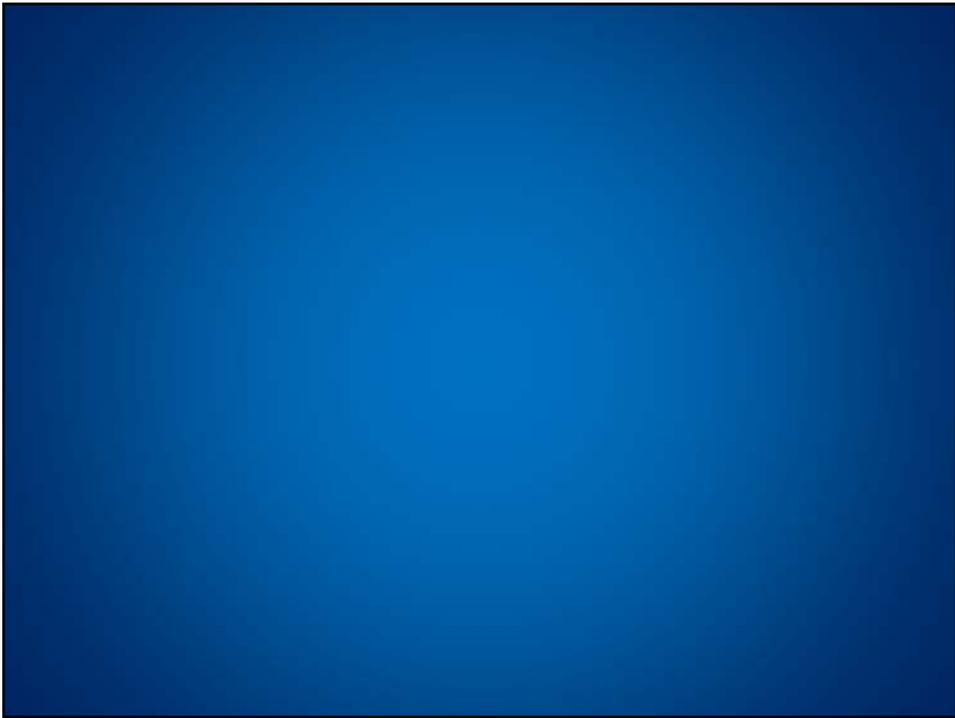
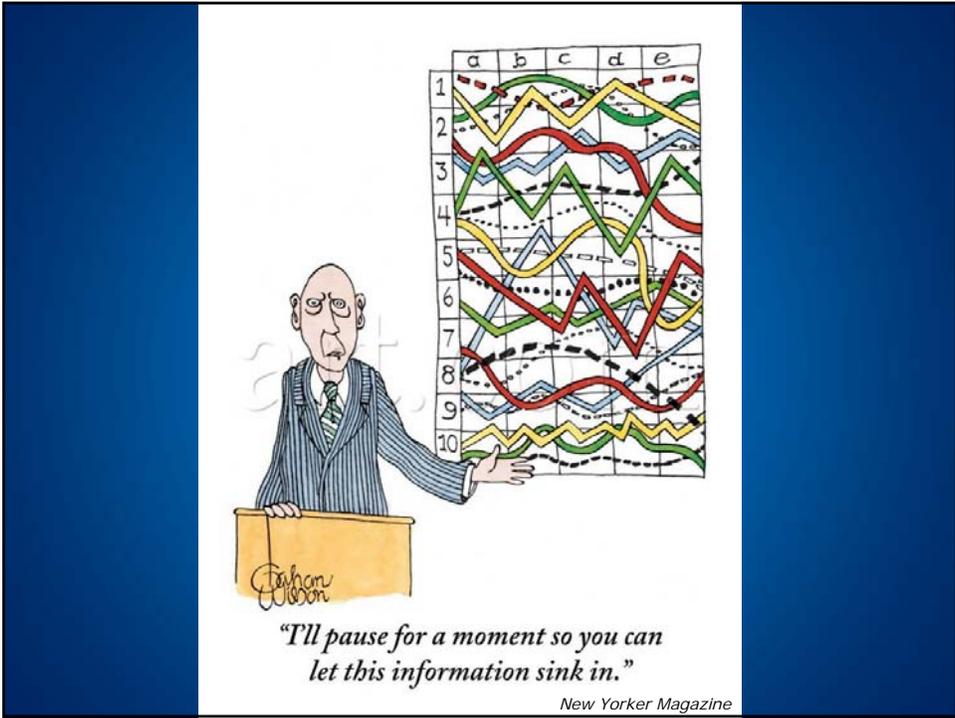


## Post-operative

- **Selective use NGT decompression:**
  - Significantly lower rate of pneumonia and atelectasis (as compared to routine use)
  - No difference in aspiration rates
- **Pain Management:**
  - May help minimize PPC
  - Epidural > other routes in preventing PPC

## Post-operative

- **Nutritional Support**
  - Malnutrition and hypoalbuminemia increase the risk of PPC
  - No proven advantage to TPN over no supplementation or total enteral nutrition in reducing PPC



## Recommendation 1

- All patients undergoing non-cardiothoracic surgery should be evaluated for the presence of the following significant risk factors for PPC
  - COPD
  - Age > 60 years
  - ASA  $\geq$  II
  - Functional dependence
  - Congestive heart failure

Ann Intern Med. 2006; 144:575-580

## Recommendation 2

- Patients undergoing the following procedures are at higher risk for PPC
  - Prolonged surgery (>3 hours)
  - Abdominal surgery, thoracic surgery, neurosurgery, head and neck surgery, vascular surgery, aortic aneurysm repair
  - Emergency surgery
  - General anesthesia

Ann Intern Med. 2006; 144:575-580

### Recommendation 3

- A low serum albumin level (<35 g/L) is a powerful marker of increased risk for PPC
- Serum Albumin is recommended for:
  - All patients who are clinically suspected of having hypoalbuminemia
  - Patients with 1 or more risk factors for perioperative pulmonary complications

Ann Intern Med. 2006; 144:575-580

### Recommendation 4

- All patients who after preoperative evaluation are found to be at higher risk for PPC should receive
  - Deep breathing exercises or incentive spirometry
  - Selective use of a nasogastric tube
    - Postoperative nausea or vomiting
    - Inability to tolerate oral intake
    - Symptomatic abdominal distention

Ann Intern Med. 2006; 144:575-580

## Recommendation 5

- Preoperative **spirometry** and **CXR** should **not** be used **routinely** for predicting risk for PPC

Ann Intern Med. 2006; 144:575-580

## Recommendation 6

- The following procedures should not be used solely for reducing PPC:
  - Right-heart catheterization
  - Total parenteral nutrition or total enteral nutrition (for patients who are malnourished or have low serum albumin levels)

Ann Intern Med. 2006; 144:575-580