به نام خدا

Preoerative Evaluation

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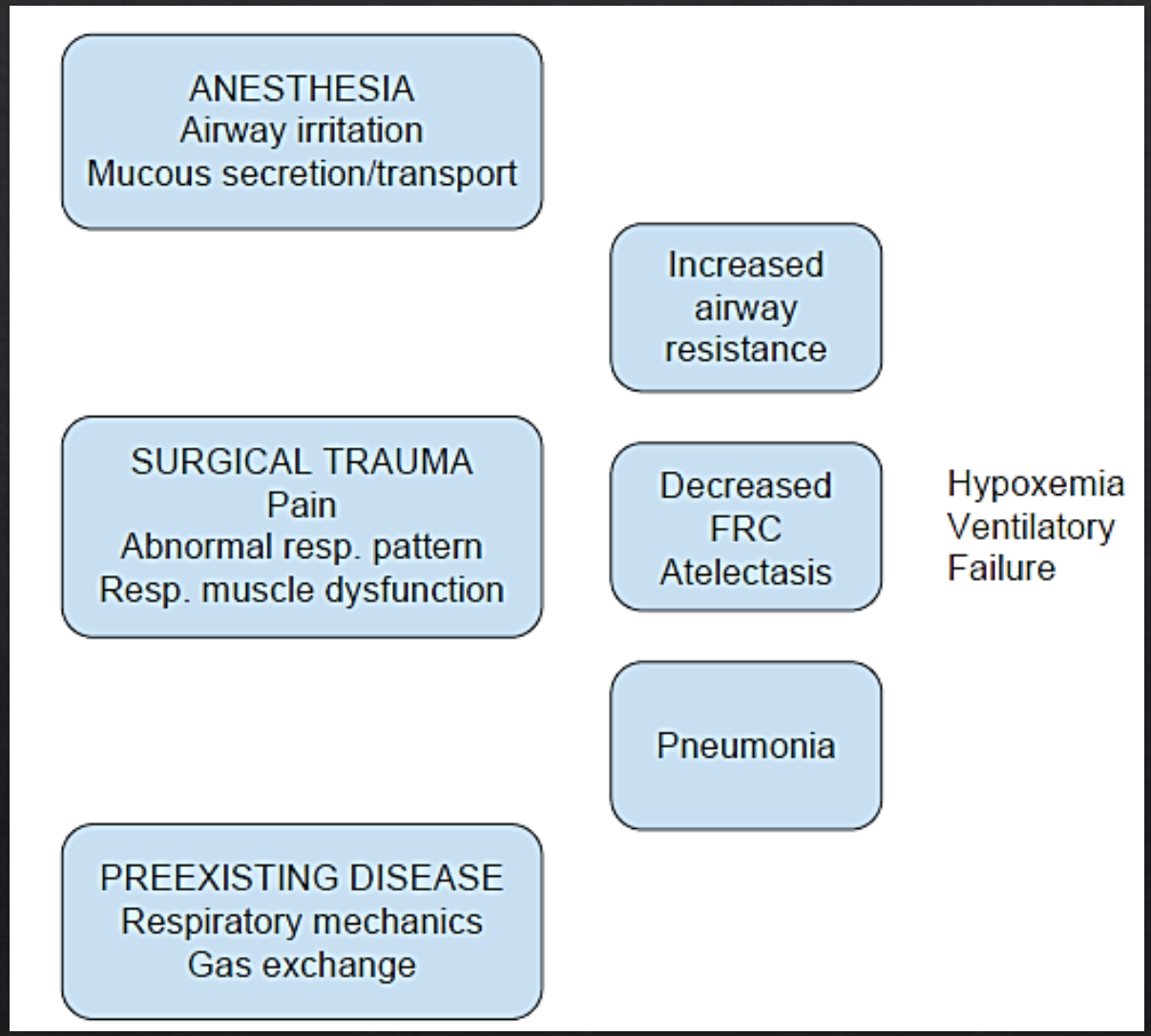
TUMS

Postoperative Pulmonary Complications

1. **Pneumonia**
2. Respiratory failure: mechanical ventilation for more than 48 hours after surgery or unplanned reintubation
3. **Atelectasis**
4. COPD exacerbation
5. **Bronchospasm**
6. Respiratory arrest due to sleep-disordered breathing
7. **Perioperative pulmonary mortality**

Mechanisms that lead to pulmonary complications in the surgical patient



Patient-Related Risk Factors

- Age>50
- ASA class ≥3
- Abnormal chest radiograph
- Heart failure
- Arrhythmia
- Total functional dependence
- COPD
- Asthma: recent studies have found no link for patients with well-controlled asthma.
- Interstitial lung disease: IPF
- Pulmonary hypertension
- Albumin less than 3 g/dL and BUN greater than 30 mg/Dl

Table 9.5 Physical findings associated with increased risk of postoperative pulmonary complications.

Finding	Technique	Odds ratio (95% CI)	*P* value
Positive cough test	Coughing once after deep inspiration triggers recurrent coughing	4.3 (1.5–12.3)[a] 3.84 (1.51–9.80)[b]	0.01 0.01
Positive wheeze test	Wheezing after five deep inspirations/ expirations	3.4 (1.2–9.4)[a] 0.94 (0.12–7.08)[b]	0.04 1.00
Forced expiratory time ≥9 seconds	Duration of forced exhalation after one deep inspiration	5.7 (2.3–14.2)[a] 4.28 (1.22–15.02)[b]	0.0002 0.04
Maximum laryngeal height ≤4 cm	Distance between the sternal notch and the top of the thyroid cartilage at end expiration	6.9 (2.7–17.4)[a] 1.17 (0.44–3.12)[b]	<0.0001 0.79
Wheezing on standard auscultation	Presence or absence of wheezing on standard thoracic exam	3.1 (0.9–10.0)[a] 2.39 (0.54–10.51)[b]	0.13 0.23

ASA PS Classification	Definition of Patient Status
ASA I	Normal health
ASA II	Mild systemic disease
ASA III	Severe systemic disease
ASA IV	Severe systemic disease that is constant threat to life
ASA V	Moribund, not expected to survive without operation
ASA VI	Declared brain-dead

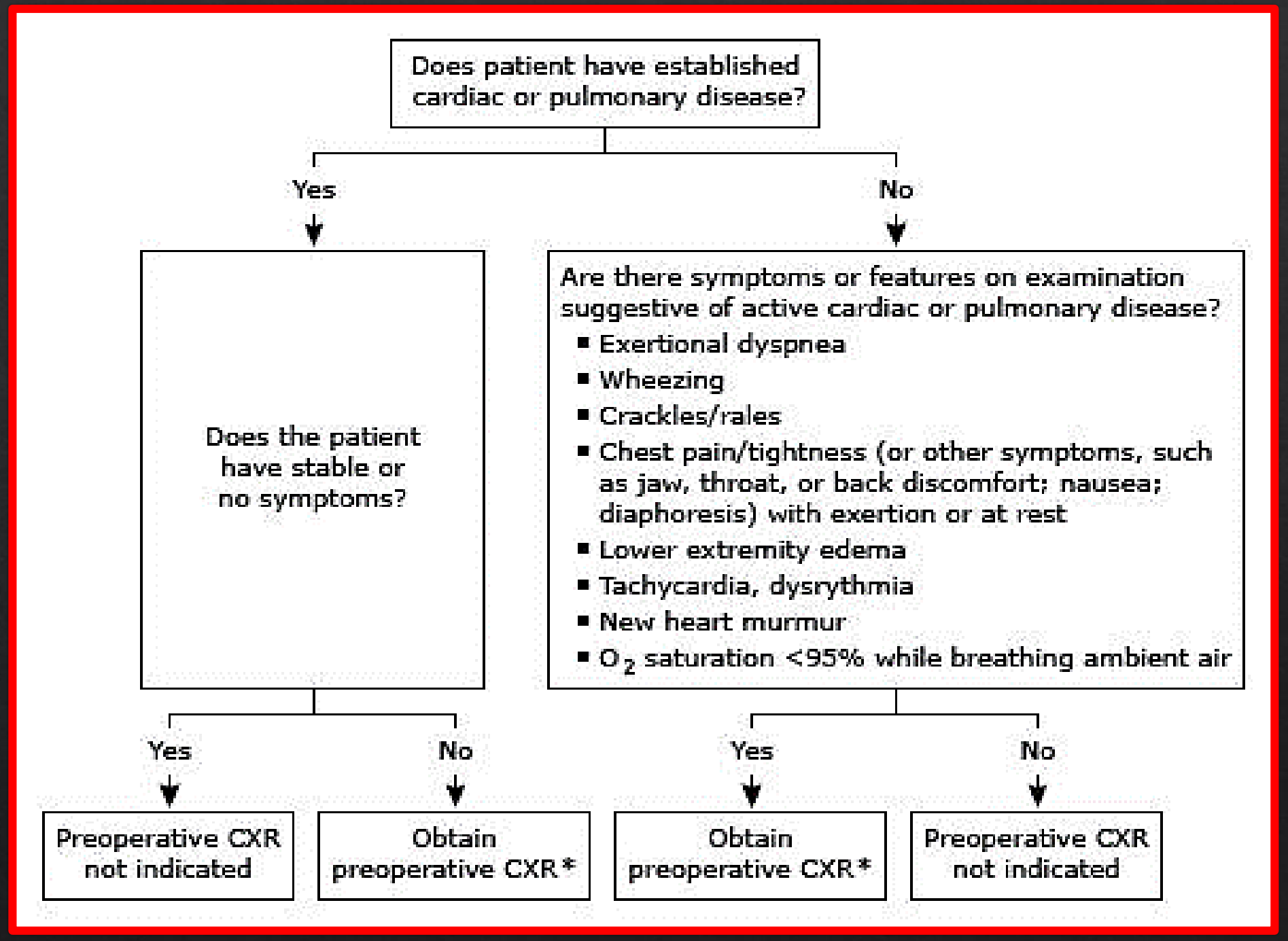
ASA indicates American Society of Anesthesiology.

Procedure-Related Risk Factors

- Aortic and non resective thoracic (esophageal) surgeries carry the greatest risk.
- Upper abdominal surgery, cholecystectomy, has more risk than lower abdominal .
- Prolonged surgery (>3–4 h)
- Neurosurgery, head and neck, and non aortic vascular surgeries.
- General anesthesia leads to a higher risk than does epidural or spinal anesthesia.

Chest Radiography

- Chest radiography for patients with evidence of acute cardiopulmonary disease.
- Older than 70 years with a history of chronic stable cardiopulmonary disease who have not had imaging within 6 months.
- All thoracic surgery patients undergo chest radiography.
- We suggest not obtaining routine preoperative chest radiographs.
- Indication: new exertional dyspnea, wheezing, angina, orthopnea, lower extremity edema, hypoxemia, rales/rhonchi, or heart murmur.
- We suggest chest imaging at least two weeks prior to surgery (treatment of undiagnosed or worsening cardiopulmonary disease)


Does patient have established cardiac or pulmonary disease?
Yes
No
Does the patient have stable or no symptoms?
Are there symptoms or features on examination suggestive of active cardiac or pulmonary disease?
Exertional dyspnea
Wheezing
Crackles/rales
Chest pain/tightness (or other symptoms, such as jaw, throat, or back discomfort; nausea; diaphoresis) with exertion or at rest
Lower extremity edema
Tachycardia, dysrythmia
New heart murmur
O_2 saturation <95% while breathing ambient air
Yes
No
Yes
No
Preoperative CXR not indicated
Obtain preoperative CXR*
Obtain preoperative CXR*
Preoperative CXR not indicated

Pulmonary Function Testing

- PFTs are not needed in the majority of patients undergoing extrathoracic surgery.
- PFT and DLCO measurement are standard for preoperative evaluation for lung resection.
- Avoid obtaining routine spirometry on patients scheduled for cardiac surgery without signs or symptoms of new or worsened cardiopulmonary symptoms.
- Preoperative PFT should be reserved for patients undergoing lung resection or with evidence of acute or worsened cardiopulmonary disease.

Pulmonary Function Testing

- PFTs may be useful in patients with known or suspected respiratory disease (eg, reduced exercise tolerance, dyspnea, cigarette smoking >20 years, COPD, ILD).
- Obtain PFTs prior to cardiac surgery in patients with respiratory symptoms that may be attributable to cardiac disease or undiagnosed respiratory disease.
- increased risk that included the following:
  - FEV1 <70 percent predicted
  - FVC <70 percent predicted
  - FEV1/FVC ratio <0.65

Arterial Blood Gas

- Limited value for perioperative management, even before lung resections.
- Hypercapnia during preoperative evaluation does not substantially alter clinical risk stratification or perioperative management in most patients with chronic lung disease.
- ABG to evaluate new or worsened respiratory symptoms is reasonable.
- Elevated serum bicarbonate in OSA patients suggests chronic CO2 retention and the presence of OHS or overlapping obstructive lung disease.
- Delaying non-urgent surgery: for further evaluation of suspected sleep apnea with evidence of hypoxemia or CO 2 retention.

Arterial Blood Gas

- Arterial hypoxemia (pO2 <50 to 60 mm Hg) is a contraindication to lung resection.
- Desaturation >4% during stair climbing exercise is another marker of increased surgical risk, and is a better predictor of outcomes than saturations decreasing below 90%.
- Thus, although hypercapnia, is not a contraindication to surgery, surgery is frequently precluded in hypercapnic patients because of a low predicted postoperative FEV1 or poor exercise performance.
- Indication for ABG : resting SpO2 <93 percent, an abnormal serum bicarbonate, and severe abnormalities on PFTs (eg, FEV1 <1 liter).
- High risk of postoperative pulmonary complications among patients with a PaCO2 >45 mmHg.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ESTIMATING POSTOPERATIVE PULMONARY RISK

- **ARISCAT : estimate of the risk of any postoperative pulmonary complications.**
- **The two Gupta risk calculators : establish the risk of a single complication, either pneumonia or respiratory failure.**
- **The Arozullah index: in research settings, as the tool is too complicated to use in clinical practice.**

The Arozullah respiratory failure index

- **Predicts the incidence of PRF (mechanical ventilation for 48 hours).**

Predicting likelihood of respiratory failure based on total points		
Class	**Point total**	**Percent respiratory failure**
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

Table 9.7 Respiratory failure risk index.

Preoperative predictor	Point value
Type of surgery	
Abdominal	27
Thoracic	21
Neurosurgery, upper abdominal, peripheral vascular	14
Neck	11
Emergency surgery	11
Albumin <3 g/dL	9
Blood urea nitrogen >30 mg/dL	8
Partially or fully dependent functional status	7
History of chronic obstructive pulmonary disease	6
Age (years)	
>70	6
60–69	4

Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT)

- **PPC outcomes included respiratory infection, respiratory failure, pleural effusion, atelectasis, pneumothorax, bronchospasm, and aspiration pneumonitis.**
- **This tool has the potential to become the gold standard multivariable risk index to predict PPCs.**

Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT)

0 to 25 points:	Low risk: 1.6% pulmonary complication rate
26 to 44 points:	Intermediate risk: 13.3% pulmonary complication rate
45 to 123 points:	High risk: 42.1% pulmonary complication rate

Age

- ◯ ≤50 years old (0 points)
- ◯ 51 to 80 years old (3 points)
- ◯ >80 years old (16 points)

Preoperative pulse oxygen saturation (SpO_2)

- ◯ ≥96% (0 points)
- ◯ 91 to 95% (8 points)
- ◯ ≤90% (24 points)

Other clinical risk factors

- ☐ Respiratory infection in the last month (17 points)
- ☐ Preoperative anemia with hemoglobin ≤10 g/dL (11 points)
- ☐ Emergency surgery (8 points)

Surgical incision

- ◯ Upper abdominal (15 points)
- ◯ Intrathoracic (24 points)

Duration of surgery

- ◯ <2 hours (0 points)
- ◯ 2 to 3 hours (16 points)
- ◯ >3 hours (23 points)

Table 9.1 Risk factors for postoperative pulmonary complications.

	Strong evidence[a]	Fair evidence[a]	Indeterminate
Patient-related factors	Advanced age	History of smoking	Respiratory infection in the last month[6]
	ASA class >2	Impaired sensorium	GERD[7]
	Congestive heart failure	Weight loss	Alcohol use[7,8]
	Functional dependence	Alcohol use	Diabetes mellitus[7,8]
	COPD		Weight loss[8]
			Obesity[8]
			Moderate/severe obstructive sleep apnea[9]
			Hypertension[8]
			Liver disease[1,8]
			Cancer[8]
			Sepsis[5,8]
			Asthma[10]
			Renal failure[11]
			Ascites[2]
			Diabetes mellitus[7,8] Preoperative shock[2]

Procedure-related factors	Aortic aneurysm	Transfusion	Prolonged hospitalization[8]
	Thoracic		Procedures with a high risk for ALI/ARDS[7]
	Abdominal		Procedures with a risk for UEPI[8]
	Upper abdominal		Perioperative nasogastric tube[12,13]
	Neurosurgery		Use of long-acting neuromuscular blockers[14]
	Prolonged surgery (>3 hours)		Mechanical ventilation strategy[11]
	Head and neck		Open abdominal surgery (vs. laparoscopic)[15]
	Emergency		Neostigmine[16]
	Vascular		Failure to use peripheral nerve stimulator[16]
	General anesthesia		
	Blood transfusion		

Lab/preoperative testing	Low serum albumin	Chest radiograph	Positive cough test[6,10]
		Blood urea	Low preoperative oxygen saturation[6]
			Anemia [6]
			Generic variations[17]
			Increased creatinine[18]
			Abnormal liver function test results[8]
			Predicted maximal oxygen uptake[19]
			$FEV_1/FVC < 0.7$ and $FEV_1 < 80\%$ of predicted[15]

Preoperative Risk Reduction Strategies

- Clinicians should fully optimize PFT before surgery and delay elective procedures if acute or worsening respiratory problems are present.
- All medications (except theophylline) used for chronic pulmonary disease are safe to continue through the perioperative period.
- Strategies to reduce PPC: for those at higher than average risk, such as those undergoing upper abdominal or open thoracic surgery with at least one other risk factor.

Preoperative Interventions for Reduction of Postoperative Pulmonary Complications

- Optimization of chronic lung disease
- Education about postoperative care
- Smoking cessation
- Inspiratory muscle training or cardiopulmonary rehabilitation (e.g., prehabilitation)
- Oral hygiene

Smoking Cessation

- Optimal reduction of PPCs requires cessation for at least 4 to 8 weeks (even shortly before surgery).
- Varenicline in the perioperative setting has also been associated with increased long-term abstinence and does not increase perioperative risk.
- All patients elective surgery to quit smoking as soon as possible, regardless of the anticipated date of surgery.
- When time allows, a longer duration (at least eight weeks) of cessation is optimal.

Prehabilitation

- Before surgery, has shown great promise for reducing PPCs. (least 1 to 2 weeks before surgery)
- Increase inspiratory muscle strength, lung capacity, and mucociliary clearance.
- Pulmonary prehabilitation includes activities such as aerobic exercises, breathing exercises, and inspiratory muscle training, reduce PPC among patients undergoing elective lung, cardiac, or abdominal surgery.

Chronic obstructive lung disease

- **COPD should be aggressively treated in order to achieve their best possible baseline level of function.**
- **For patients who present with symptoms or signs suggestive of an exacerbation of COPD, elective surgery should be delayed pending treatment and a return to baseline pulmonary function.**

Asthma

- Poorly controlled asthma is a risk factor for the development of PPC.
- Asthma should undergo a preoperative evaluation to assess asthma control.
- Asthma is not well controlled should receive a step-up in asthma therapy.
- Brief course of systemic glucocorticoids in patients whose FEV1 or PEF are substantially below their predicted values or personal best.
- For elective surgery, patients should be free of wheezing and have a peak expiratory flow rate greater than 80 percent of predicted or of their personal best prior to surgery.

Asthma

- For patients who require endotracheal intubation, we suggest administering an inhaled rapid-acting beta agonist two to four puffs or a nebulizer treatment within 30 minutes before intubation.
- Inhaled beta agonists may be continued as needed in the perioperative period.
- Inhaled beta agonists can be used in the circuit of anesthesia tubing for prolonged procedures, and for patients still intubated immediately after surgery.
- One to two days of systemic glucocorticoid therapy has sometimes been advised as a method to prevent acute bronchoconstriction at the time of intubation.

Asthma

- Preoperative systemic glucocorticoids be reserved for patients with poorly-controlled asthma.
- Patients with aspirin exacerbated respiratory disease (AERD) characterized by asthma, chronic rhinosinusitis with nasal polyposis, and aspirin sensitivity should not receive NSAIDs for pain control.
- As with COPD, patients who are currently taking exogenous glucocorticoids may be candidates for perioperative stress-dose glucocorticoids.

Antibiotics

- Preoperative antibiotics are not useful for prevention of pneumonia in patients with stable COPD or asthma.
- Preoperative antibiotics are only indicated in patients with a clinically apparent lower respiratory tract infection, acute bronchitis or a flare of COPD or bronchiectasis: manifest by purulent sputum or a change in the character of sputum.
- Elective surgery should e cancelled until such treatment is completed and patient's sputum production has returned to baseline.

COVID-19

- **Increased risk of pulmonary complications and mortality in surgical patients with concomitant SARS-CoV-2 infection.**
- **Risk of complications remains elevated for at least seven weeks after infection and even longer in patients with persistent symptoms.**

Oral Hygiene

- Several studies of daily oral care (toothbrushing and antigingivitis rinse use, chlorhexidine mouthwash) for up to 2 weeks preoperatively found decreased rates of pneumonia in patients undergoing cardiac surgery, lung resection, esophagectomy, and other abdominal procedures.

Preoperative strategies
Smoking cessation: preferably more than eight weeks prior to surgery (however, briefer periods of cessation are not harmful and may still provide nonrespiratory benefits)
For patients with COPD or asthma, optimize control with inhaled bronchodilators and possibly inhaled glucocorticoids
For patients with a flare of COPD or asthma, administer systemic glucocorticoids (eg, prednisone 40 mg/day for five days) and delay elective surgery until COPD/asthma is under good control and has returned to baseline
Reserve preoperative antibiotics for patients with symptoms and signs of lower respiratory infection*
Delay elective surgery for at least 30 days for patients with lower respiratory tract infection and at least six weeks for patients with COVID-19
Counsel patients on preoperative oral care (eg, dental hygienist visit, preoperative chlorhexidine mouthwash)
Provide preoperative education regarding lung expansion maneuvers
For patients at increased risk of pulmonary complications, initiate chest physical therapy (eg, aerobic exercises, breathing exercises, inspiratory muscle training) up to two weeks before surgery

Anesthesia

- **Neuraxial (spinal or epidural) anesthesia reduces the risk of postoperative PPCs.**
- **Neuromuscular blocking agents (NMBA) are usually administered to facilitate laryngoscopy for endotracheal intubation.**
- **Use of *neuromuscular blockade* (NMB) is associated with increased risk of postoperative respiratory failure and pneumonia.**
- **Short or intermediate acting non depolarizing NMBAs (eg, cisatracurium, mivacurium, rocuronium, vecuronium) are preferred over longer acting agents.**
- **Avoidance of long-acting neuromuscular blocking agents (e.g., pancuronium).**
- **Risk of pulmonary complications due to general anesthesia when compared with spinal or epidural (neuraxial) anesthesia.**

Mechanical Ventilation

- **Lung-protective ventilation reduces the risk of PPCs.**
- Supra physiologic VT (i.e., ≥10 mL/kg) is inferior to near physiologic VT (i.e., 6–8 mL/kg) with these open lung interventions.
- **Direct correlation between high airway driving pressure and risk for PPCs.**
- Plateau pressures less than 16 cm H 2 O were associated with the lowest risk of PPCs.
- **Avoid extremes of VT (<6 or >10 mL/kg), PEEP, and airway pressures.**
- Emphasize open lung techniques, such as PEEP and alveolar recruitment maneuvers, to balance the risks of alveolar collapse, barotrauma, and impaired hemodynamics.

Intraoperative strategies
Choose shorter procedure (less than three hours) when possible
Choose less invasive procedure when possible (eg, laparoscopic), as long as operative time not prolonged
Consider neuraxial anesthesia rather than general anesthesia
Utilize regional anesthesia (nerve block) when this is an option
For patients with COPD or asthma, administer inhaled short-acting beta-adrenergic (eg, albuterol) 2 to 4 puffs within 30 minutes before intubation
When invasive mechanical ventilation is used, use lung-protective ventilation methods (ie, lower tidal volume [6-8 mL/kg], higher positive end-expiratory pressure [6 to 8 cm H_2O], alveolar recruitment maneuvers)
Avoid long-acting neuromuscular blocking agents for induction or during procedure
Assure full reversal of neuromuscular blocking agents with appropriate use of reversal agents and quantitative monitoring, if available

Postoperative Interventions for Prevention of Postoperative Pulmonary Complications

- Early and frequent ambulation/mobilization
- Lung expansion maneuvers (cough/deep breathing exercises, CPAP)
- Adequate pain control
- Minimization of systemic opioids (including by the use of nerve blocks, epidural analgesia, and PCA)
- Maximization of non opioid analgesia (acetaminophen, NSAIDs, and application of ice)

Postoperative Interventions for Prevention of Postoperative Pulmonary Complications

- Expand the lungs is by cough and deep breathing exercises. (??)
- Incentive spirometry utilize preoperative education on its use, and these protocols have demonstrated reductions in PPC rates.
- Intermittent positive pressure breathing is likely best reserved for patients at high risk for PPCs who are unable or unwilling to comply with incentive spirometry or deep breathing exercises.

Postoperative Interventions for Prevention of Postoperative Pulmonary Complications

- CPAP immediately after extubation and continued for as little as an hour significantly reduces the incidence of PPCs after major abdominal surgery.
- High-flow nasal oxygen, CPAP, and noninvasive ventilation may reduce the rate of reintubation among postoperative who develop respiratory insufficiency.
- CPAP after abdominal procedures.

Postoperative Interventions for Prevention of Postoperative Pulmonary Complications

- Nasal CPAP (CPAP at 10 cm H2O continuously for six hours) or the institution's usual care (CPAP at 10 cm H2O for 10 minutes every four hours) after cardiac surgery, continuous (≥6 hours) CPAP improved oxygenation and reduced the incidence of pneumonia, reintubation, and admission to an ICU.
- Immediate postoperative institution of intermediate levels of CPAP for short duration (as little as one hour) was as effective at reducing PPC as higher levels of CPAP for extended duration.

Postoperative strategies
Initiate deep breathing exercises or incentive spirometry in high-risk patients; noninvasive ventilatory support (CPAP, high-flow nasal oxygen, or noninvasive ventilation) may also be beneficial in patients with early respiratory compromise
Provide epidural analgesia in place of parenteral opioids, as appropriate
For patients with asthma and AERD, avoid using NSAIDS for pain control (eg, ketorolac, ibuprofen)
Avoid use of nasogastric tubes after abdominal surgery (unless needed for symptom control)
Use enhanced recovery pathways and goal-directed hemodynamic therapy in high-risk patients if appropriate resources and protocols available

I COUGH Pulmonary Risk Reduction Protocol

I	Incentive spirometry
C	Cough and deep breathing exercises
O	Oral care (brushing teeth and using mouthwash twice daily)
U	Understanding (patient and family education)
G	Getting out of bed frequently (at least three times daily)
H	Head of bed elevation

Sleep-Disordered Breathing Considerations

- The incidence of moderate or severe OSA has been found to be as high as 40% of surgical patients.
- Screen all surgical patients for the presence of sleep apnea.
- Patients with known OSA or an elevated STOP-BANG score are at increased risk for perioperative complications and should receive risk reduction interventions.
- STOP-BANG cutoff score to use for high risk is 5 or greater.

Sleep-Disordered Breathing Considerations

- Patients using home PAP therapy should be encouraged to bring their device to the hospital for perioperative use.
- For patients without diagnosed sleep apnea who have high STOP-BANG scores, SASM does not recommend delaying all surgical procedures for further sleep evaluation. (Murray)

Sleep-Disordered Breathing Considerations

S	Snoring loudly
T	Tired, fatigued, or sleepy during the daytime
O	Observed episodes (by others) of stopped breathing during sleep
P	High blood pressure history or treatment
B	Body mass index > 35 kg/m^2
A	Age > 50 years
N	Neck circumference > 17 inches for a man or > 16 inches for a woman
G	Male gender

Table 9.4 STOP-BANG score.

1. Snoring	Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?
2. Tired	Do you often feel tired, fatigued, or sleepy during daytime?
3. Observed apnea	Has anyone observed you stop breathing during your sleep?
4. Blood pressure	Do you have or are you treated for high blood pressure?
5. BMI	Is it more than a 35 kg/m^2?
6. Age	Age over 50 years old?
7. Neck circumference	Neck circumference greater than 40 cm?
8. Gender	Gender male?
Score 1 point for each positive outcome.	
Interpretation: 0–2 = low risk; 3–4 = medium risk; 5–8 = high risk for OSA	

Sleep-Disordered Breathing Considerations

- Only delay surgery for patients with elevated STOP-BANG scores plus one of the following:
  1. Uncontrolled or severe systemic disease (e.g., pulmonary hypertension),
  2. Hypoxemia,
  3. Evidence of CO2 retention (elevated arterial blood CO2 or serum bicarbonate).
- The anesthesia team should consider use of regional anesthesia methods and be prepared for a difficult airway.

Sleep-Disordered Breathing Considerations

- Use benzodiazepines and opioids with caution.
- After surgery, non opioid analgesia, non supine position (i.e., head of bed elevated).
- Continuous pulse oximetry or capnography during hospitalization is also recommended for all patients.
- Sleep-disordered breathing is increased perioperatively, and this worsening reaches a peak at 3 days after surgery.