REVIEW ARTICLE
PRE-OPERATIVE PULMONARY EVALUATION

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Postoperative pulmonary complications contribute significantly to morbidity and morality in surgical patients. Pulmonary complications occur more frequently than cardiac complications. The complication rates for upper abdominal and thoracic surgery are the highest. A better understanding of the risk factors associated with postoperative pulmonary complications is essential to develop strategies for reducing these complications. In any individual patient the benefit from a surgical procedure should be weighed against the risks it imposes. When possible, stabilization of respiratory status is advisable before surgery. This article reviews patient and procedure related risk factors, clinical and laboratory evaluation for preoperative risk assessment and risk reduction strategies to minimize the complication rates.

INTRODUCTION

Postoperative pulmonary complications contribute to increased mortality and prolong hospital stay. Pulmonary complications occur more frequently than cardiac complications in patients undergoing non-cardiac surgery.[1] These complications prolong the hospital stay or are responsible for increased morbidity and mortality.[2,3] Complications may arise from pneumonia, atelectasis, respiratory failure, bronchospasm and exacerbation of underlying chronic lung disease.

This article reviews patient and procedure related risk factors, clinical and laboratory evaluation for preoperative risk assessment and risk reduction strategies to minimize the complication rates.

PATIENT RELATED RISK FACTORS

Age: Age is a minor risk factor when adjusted for other co-morbid conditions.[4] In a study on patients having endovascular repair of abdominal aortic aneurysms, American Society of Anaesthesiology (ASA) risk class 3 or 4, and advanced age were independent risk factors for perioperative death and complications.[5,6] Table 1 summarizes the ASA classification. Other studies have shown that age was not a predictor for postoperative pulmonary complications.[7] Surgery should not be declined in elderly patients who are otherwise acceptable surgical candidates.

Obesity: Morbid obesity causes restrictive lung disease, decreases thoracic compliance, and leads to alveolar hypoventilation. In a review of 169 patients treated for acetabular fracture, obese subjects (BMI $\geq$ 30) were more likely to have complications than patients of normal weight (body mass index of <25).[7] In another review of morbidly obese patients undergoing gastric bypass surgery, incidence of postoperative pulmonary complications was 3.9 percent, a rate similar to that for non-obese patients.[8]

Smoking: Smoking is an important risk factor for postoperative complications. Following coronary artery bypass surgery current smoker were more likely to develop pulmonary complications, require ventilation longer than 48 hrs and had significantly increased mortality during follow-up.[9] Patients who had stopped smoking for less than two months had a pulmonary complication rate of almost 4-times that of patients who had stopped for more than two months (57% vs. 14.5%). Those who quit smoking for more than six months had complications rates similar to those who had never smoked (11% vs. 11.9%).[10] Smoking history of 40 pack years or more was strongly associated with increased risk of pulmonary complications.[11]

Table 1: American Society of Anesthesiologists Classification

Class I: There is no organic, physiologic, biochemical, or psychiatric disturbance. The pathologic process for which the operation is to be performed is localized and is not a systemic disturbance.
Class II: Mild to moderate systemic disturbance caused either by the condition to be treated surgically or by other pathophysiological processes.
Class III: Severe systemic disturbance or disease from whatever cause, even though it may not be possible to define the degree of disability with finality.
Class IV: Indicative of the patient with severe systemic disorder already life-threatening, not always correctable by the operative procedure.
Class V: The moribund patient who has little chance of survival but is submitted to the operation in desperation.

General health status: Patients who have poor exercise capacity are at increased risk of developing postoperative complications.[12] The American Society of Anesthesiologists classification and Goldman cardiac risk index that include factors from history, physical examination and laboratory data, have

helped successfully predict the risk of pulmonary complications.[13,14]

Chronic obstructive pulmonary disease (COPD): Patients with COPD are at increased risk of developing postoperative complications. Those with severe COPD are six times more likely to have major postoperative complication.[15] Despite the increased risk, a prohibitive level of pulmonary function for an absolute contraindication is not apparent. The benefits of surgery must be weighed against these complications. A careful preoperative evaluation of patients with COPD should include identification of high-risk patients and optimizing their treatment before surgery.

Asthma: Inadequate control of asthma increases the risk of postoperative complications. In children presence of asthma was associated with an increased risk (O.R. 4.4; 95% CI 2.13-9.0) of respiratory complications after adenotonsillectomy.[16] Asthmatic patients treated with corticosteroids before surgery have a low incidence of complications.[17]
Table 2 summarizes the patient related risk factors for postoperative pulmonary complications.

PROCEDURE RELATED RISK FACTORS

Surgical site: It is the most important predictor of pulmonary complications. The incidence of complications is inversely related to the distance of the surgical incision from the diaphragm. The complication rates for upper abdominal and thoracic surgery are the highest (range 10% to 40%).

Duration and type of anaesthesia: Anesthesia time of greater than 3.5 hours was associated with increased incidence of pulmonary complications.[18] Epidural or spinal anesthesia reduces postoperative pulmonary complications.[19] It reduced the odds of deep vein thrombosis by 44%, pulmonary embolism by 55%, pneumonia by 39%, and respiratory depression by 59%.

PREOPERATIVE RISK ASSESSMENT

Clinical evaluation: A complete history and a good physical examination will help to identify risk factors associated with postoperative complications. History of smoking, poor exercise tolerance, unexplained dyspnea or cough should be noted. Presence of decreased breath sounds, wheezes, crackles or a prolonged expiratory phase on physical examination may identify an unrecognized pulmonary disease which may increase the risk of pulmonary complications.[20]

Pulmonary function tests: There is consensus that all candidates for lung resection should have preoperative pulmonary function test (PFT). The American College of Physicians consensus statements[21] recommends preoperative PFT in the further two groups:
a) Patients undergoing coronary bypass or upper abdominal surgery with a history of smoking or dyspnea.
b) Patients undergoing head and neck, orthopedic, or lower abdominal surgery with unexplained dyspnea or pulmonary symptoms.
Preoperative PFT does not identify patients in whom the risk is so high that surgery should be cancelled. Even patients with severe COPD, classified as very high risk by spirometry can undergo surgery with an acceptable risk of pulmonary complications. Therefore, the results from PFT should be interpreted in context of clinical situation and should not be the sole reason to withhold necessary surgery.

Spirometry: No single value on spirometry can absolutely contraindicate non-thoracic surgery, but less invasive procedure should be considered if the risks are known to be high. There is higher risk of postoperative pulmonary complications in patients with a forced expiratory volume in one second (FEV_1) or forced vital capacity (FVC) of less than 70% predicted, or FEV_1/FVC ratio of less than 65%.[22]

Table 2: Patient related risk factors for postoperative pulmonary complications[8]

Risk Factors	Type Of Surgery	Incidence of Pulmonary Complications (%)	
		Factor Present	Factor Absent
Age>65 yr	Unselected Thoracic or abdominal	09 – 17 17 – 22	04 - 09 12 – 21
Obesity	Unselected Thoracic or abdominal	11 19 – 36	09 17 – 27
Smoking	Coronary bypass Abdominal	39 15 – 46	11 06 – 21
ASA class >II	Unselected Thoracic or abdominal	26 26 – 44	16 13 – 18
COPD	Unselected Thoracic or abdominal	06 – 26 18	02 – 08 04

*ASA: American Society of Anaesthesiologists

Arterial blood gases: Hypercapnia with a $PaCO_2$ of greater than 45 mm Hg is a strong risk factor for pulmonary complications,[23] although it is not necessarily an absolute contraindication for surgery.[24] Hypoxemia is less significant predictor of complications. Patients undergoing thoracic, cardiac or abdominal surgery who have dyspnea or who smoke should have preoperative analysis of arterial blood gases.

Table 3 shows the risk of postoperative pulmonary complications in relation to pulmonary function test.

Table 3: Risk of postoperative pulmonary complications in relation to pulmonary function tests[11]

Variable	Number of Patients	Odds Ratio(95% Confidence Interval)	P Value
Spirometry	145	0.84 (0.53-1.35)	0.78
FEV1 < 1 L/min	10	7.9 (1.7-37.0)	0.02
FVC < 1.5 L/min	08	11.1 (2.2-56.4)	0.005
Arterial blood gases	66	0.7 (0.3-1.8	0.61
PCO2 ≥ 45 mm Hg	03	61.0 (3.8-6.4)	0.001
PO2 < 75 mmHg	14	13.4 (1.3-14.1)	0.008

Chest radiography: In clinical practice, chest radiography is beneficial only in patients who have clinical evidence of chest disease.[11]

RISK REDUCTION STRATEGIES

PREOPERATIVE STRATEGIES

One of the goals of pulmonary evaluation before surgery is to identify high-risk patients in whom prophylactic measures may reduce the risk of postoperative complications.

Smoking cessation: Patients undergoing elective surgery should be encouraged to abstain from smoking for at least 8 weeks before surgery.[25] Counseling accompanied with nicotine replacement or bupropion therapy improves the success rate. Two small trials have shown that smoking cessation reduces risk of postoperative complications.[26]

COPD: Patients with COPD should be treated aggressively to achieve their best possible baseline function. Bronchodilators, smoking cessation, antibiotics, and chest physical therapy may help significantly to reduce pulmonary complications. It is reasonable to give preoperative course of systemic steroids to patients who continue to have symptoms despite bronchodilator therapy.

Asthma: Patients with asthma should have an evaluation before surgery that includes a review of symptoms, medication use (particularly the use of systemic corticosteroids for longer than 2 weeks in the past 6 months), and measurement of pulmonary function. A short course of systemic corticosteroids may be necessary to optimize pulmonary function. For patients who have received systemic corticosteroids during the past 6 months, give 100 mg hydrocortisone every 8 hours intravenously during the surgical period and reduce dose rapidly within 24 hours following surgery.[27]

Preoperative antibiotics: Indiscriminate use of prophylactic antibiotics does not lead to a reduction in pulmonary complications and should be avoided.

Patient education: Lung expansion, deep breathing and coughing, and incentive spirometry techniques are best taught to the patient prior to surgery.

INTRA-OPERATIVE STRATEGIES

Type of anesthesia: The type of anesthesia and neuromuscular blockage affects the incidence of postoperative pulmonary complications. Intermediate and shorter acting agents are preferred because residual neuromuscular blockade from longer acting agents may contribute to pulmonary complications. Spinal anesthesia is safer than general anesthesia for high-risk patients.[19]

Duration and type of surgery: The duration of the surgical procedure is known to affect rate of postoperative complications. When available, a less ambitious, shorter procedure should be considered in high-risk patients. Because upper abdominal and thoracic operations carry the greatest risk, a laparoscopic procedure should be preferred over an open procedure if possible.

POST OPERATIVE STRATEGIES

Lung expansion maneuvers: Deep breathing exercises and incentive spirometry both appear to be equally effective.[28] They have been shown to reduce postoperative pulmonary complications in high-risk patients. Postoperative continuous positive airway pressure (CPAP) decreases the incidence of pulmonary complications after major abdominal surgery.[29]

Pain control: Adequate postoperative pain control helps minimize pulmonary complications by encouraging early ambulation and performance of lung expansion maneuvers.[30] Management of postoperative pain includes use of opoid narcotics and related medications. These can be administered into the epidural or intrathecal space. Intrathecal administration of narcotics is associated with a longer duration of analgesia (15-22 h) but may be associated with respiratory depression and headaches. Recent studies have popularized the use of epidural analgesia as an alternative to systemic analgesia. In upper

abdominal procedures, patients who received epidural analgesia had lower rates of pulmonary complications.[31]

Table 4 summarizes peri-operative risk reduction strategies that can be used to reduce postoperative complications.

Table-4: Risk reduction strategies for postoperative complications

Preoperative measures
Cessation of cigarette smoking for at least 8 weeks before surgery
Treat airflow obstruction
Treat respiratory infection if present
Educate for lung-expansion maneuvers
Intra-operative measures
Limit duration of surgery to less than 3 hours
Avoid use of pancuronium
Use spinal or epidural anaesthesia when possible
Use laproscopic procedures when possible
Postoperative measures
Epidural analgesia or intercostals nerve bloc for pain control
Early mobilization
Chest physical therapy (including deep breathing and incentive spirometry)
Continuous positive airway pressure in selected patients

CONCLUSION

Postoperative complications prolong hospital stay and adversely affect patient outcome. Preoperative assessment starts with a good clinical assessment. PFT is recommended for all patients undergoing lung resection surgery. In all other surgeries the need for investigations (PFT, ABG, chest radiograph) would depend upon presence of respiratory symptoms, and the type and duration of surgical procedure. In any individual patient the benefit from a surgical procedure should be weighed against the risks it imposes. When possible, stabilization of respiratory status is advisable before surgery.

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