Respiratory risk assessment prior to extrathoracic surgery

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Keywords: respiratory risk assessment, extrathoracic surgery

Abstract

Physicians are often asked to evaluate a patient prior to elective surgery for the purpose of risk identification and modification. Postoperative pulmonary complications are the most costly of the major postoperative medical complications, including cardiac, thromboembolic and infectious, and result in the lengthiest hospital stays. Therefore, estimation of respiratory risk should be a routine element of all preoperative medical evaluations. A diligent preoperative clinical evaluation, supplemented with appropriate preoperative pulmonary function testing, would identify the majority of important risk factors for postoperative complications. Risk reduction strategies can then be implemented to reduce complications, cost, and hospital stay.

Ⓟ **Peer reviewed. (Submitted: 2011-04-11. Accepted: 2011-11-04.)** **S Afr Fam Pract 2012;54(3):193-197**

Introduction

Physicians often need to evaluate a patient prior to elective surgery for the purpose of risk identification and modification. Postoperative pulmonary complications contribute significantly to overall perioperative morbidity and mortality. In a study of patients undergoing elective abdominal surgery, pulmonary complications occurred significantly more often than cardiac complications, and were associated with significantly longer hospital stays.[1] The United States National Surgical Quality Improvement Program also found that pulmonary complications were the most costly of the major postoperative medical complications, including cardiac, thromboembolic and infectious, and resulted in the longest periods of hospitalisation.[2]

As the impact of pulmonary complications following surgery has become increasingly apparent, estimation of respiratory risk should be a routine element of all preoperative medical evaluations. Most risk factors can be identified in the preoperative assessment, and most can be ameliorated in advance to some extent, to reduce the overall risk of complications.

Definition of postoperative pulmonary complications

No universal definition for postoperative pulmonary complications is currently available. This might explain the wide range of incidences reported in the literature. A proposed definition refers to pulmonary abnormalities that produce identifiable diseases or dysfunctions, that are clinically significant, and adversely affect the clinical course of the patient.[3]

These diseases or dysfunctions include the following:[4]

- Atelectasis
- Infection, including bronchitis and pneumonia
- Prolonged mechanical ventilation and respiratory failure
- Exacerbation of underlying chronic lung disease
- Bronchospasm.

Perioperative pulmonary physiology

Most postoperative pulmonary complications represent a pathological expression of the normal physiological changes that occur as a result of upper abdominal surgery and anaesthesia. These changes occur after thoracic and upper abdominal surgery, to a lesser extent after lower abdominal surgery, and more seldom after surgery to an extremity.[5]

The following mechanisms underlie the physiological changes:

- Pain
- Sedation
- Long-acting opiates and neuromuscular blockade
- Duration of surgery and anaesthesia
- Diaphragm dysfunction
- Supine position
- Ileus and dilatation of bowel
- Bronchospasm.

The physiological changes take the form of reduced respiratory volumes as follows:

- Vital capacity (VC) is reduced by 50-60%, and may

remain decreased for up to one week. Once below closing volumes, this results in atelectasis, pneumonia, ventilation and perfusion mismatches and hypoxemia.
- Functional residual capacity (FRC) is reduced by about 30%.
- Tidal volume and sighing breaths are reduced.
- Respiratory rate is increased.

The pathological results of these changes are the following:
- Decreased ability to cough and clear secretions
- Atelectasis
- Pneumonia
- Postoperative ventilation due to complications
- Prolonged hospital stay.[5]

Patient-related risk factors

Risk factors for pulmonary complications can be divided into patient-related, and procedure-related risks. Potential patient-related risk factors are discussed below.

Age

The influence of age as an independent predictor of postoperative pulmonary complications has been questioned. Early studies suggested an increased risk of pulmonary complications with advanced age. However, these studies were not adjusted for overall health status, or the presence of known pulmonary disease, and subsequent studies did not reliably demonstrate age as a predictor of postoperative complications. The risk of surgical mortality was similar across age groups when stratified by the American Society of Anesthesiologists' class.[6]

A more recent systematic review prepared for the American College of Physicians estimated the impact of age on postoperative pulmonary complications from studies that used multivariable analysis to adjust for age-related co-morbidities. This review observed that age > 50 years was an important independent predictor of risk. Therefore, even healthy, older patients carry a substantial risk of pulmonary complications after surgery.[7]

Chronic lung disease

Known chronic lung disease is an important patient-related risk factor for postoperative pulmonary complications. A recent review found that the impact of chronic obstructive pulmonary disease (COPD) on postoperative pulmonary complication rates was less than previously estimated. Despite the increased risk of postoperative pulmonary complications in patients with COPD, there appears to be no prohibitive level of pulmonary function below which surgery is absolutely contraindicated. The benefit of surgery must be weighed against the known risks. Even very-high-risk patients may proceed to surgery when the indication is sufficiently compelling.[8]

Asthma

Despite early reports indicating that patients with asthma had higher than expected rates of postoperative pulmonary complications, more recent studies have found no increased risk in patients with well-controlled asthma. Patients with well-controlled asthma and a peak flow measurement of > 80% of predicted or personal best, can proceed to undergo surgery with average risk.[9]

Smoking

Smoking increases risk, even among patients without chronic lung disease. The risk only declines after eight weeks of preoperative cessation. Warner et al prospectively studied 200 smokers preparing for coronary artery bypass surgery, and found a lower risk of pulmonary complications in those who had stopped smoking at least eight weeks before surgery, than in current smokers (14.5% vs. 33%).[10] Paradoxically, patients who had stopped smoking less than eight weeks prior to surgery had a higher risk than current smokers.[10]

Obesity

Physiological changes accompanying morbid obesity include the following:
- Reduction in lung volume
- Ventilation and perfusion mismatch
- Relative hypoxaemia.[11]

These findings might be expected to accentuate similar changes seen with anaesthesia, and increase the risk of postoperative pulmonary complications. However, obesity has not consistently been shown to be a risk factor for postoperative pulmonary complications. Therefore, it should not affect patient selection for otherwise high-risk procedures.[7]

Obstructive sleep apnoea

Obstructive sleep apnoea (OSA) is an emerging risk factor for postoperative pulmonary complications. It is well appreciated in the anaesthesia literature that OSA increases the risk of critical respiratory events immediately after surgery, including early hypoxemia and unplanned reintubation.[10] While the literature is still emerging, OSA should be considered to be a probable risk factor for pulmonary complications after surgery. At present, it is unknown whether patients without OSA should be screened prior to elective surgery. The use of a standardised questionnaire has been proposed, which is the subject of a current study.[12]

Pulmonary hypertension

Pulmonary hypertension increases pulmonary complication rates after surgery, which appears to be true, regardless of the underlying aetiology of the pulmonary hypertension.[13]

Risk predictors include the following:
- History of pulmonary embolus
- New York Heart Association functional class ≥ 2
- Intermediate- or high-risk surgery
- Duration of anaesthesia exceeding three hours.

The increased risk warrants careful consideration of indications for surgery, and discussion of potential risks with patients with pulmonary hypertension.

Heart failure

The risk of pulmonary complications may be higher in patients with heart failure, than in those with chronic obstructive pulmonary disease.[7] The original Goldman Cardiac Risk Index has been shown to predict postoperative pulmonary, as well as cardiac, complications.[13] Although the Revised Cardiac Risk Index is now more commonly used to estimate the risk of cardiovascular complications, validation studies of the revised index in predicting pulmonary complications have not been carried out.[14]

General health status

Overall health status is an important determinant of pulmonary risk after surgery. Both functional dependence and impaired sensorium increase postoperative pulmonary risk.[7] The commonly used American Society of Anesthesiologists' (ASA) classification correlates well with pulmonary risk, and is one of the most important predictors of pulmonary risk. The criteria for assigning ASA class include the presence of a systemic disease that affects activity, or is a threat to life. Thus, patients with significant pre-existing lung disease would be placed in a higher ASA class. Poor exercise capacity also identifies patients at risk. An inability to exercise predicts 79% of pulmonary complications.[15]

Procedure-related risk factors

Surgical site and technique of operation

Surgical site is the single most important factor in predicting the overall risk of postoperative pulmonary complications. The incidence of complications is inversely related to the distance of the surgical incision from the diaphragm. Therefore, the complication rate is significantly higher for thoracic and upper abdominal surgery, than for lower abdominal and all other procedures.[8] The higher rates of complication in upper vs. lower abdominal surgery relate to the effect upon respiratory muscles and diaphragmatic function.

Laparoscopic cholecystectomy is associated with shorter recovery times, less postoperative pain, and less reduction in postoperative lung volumes. Its impact on pulmonary complication rates is less well established. While the decrease in postoperative pain might be expected to translate into lower pulmonary complication rates, few studies have clinically evaluated important pulmonary complications as an end-point.[7]

Duration of surgery

Surgical procedures lasting more than three to four hours are associated with a higher risk of pulmonary complications.[7]

Type of anaesthesia

Conflicting data are available with regard to the pulmonary risk of spinal or epidural anaesthesia, when compared with general anaesthesia.[7] Recently, the largest systematic review of this literature to date, was conducted.[16] The review evaluated the results of 141 trials, that included 9 559 patients. The authors reported a reduction in risk of pulmonary complications among patients receiving neuraxial blockade, either epidural or spinal anaesthesia, with or without general anaesthesia, when compared to those receiving general anaesthesia alone. Patients receiving neuraxial blockade had an overall 39% reduction in the risk of pneumonia, and a 59% decrease in the risk of respiratory depression.[16]

Based upon this comprehensive review, it appears likely that general anaesthesia leads to a higher risk of clinically important pulmonary complications, than epidural or spinal anaesthesia, although further studies are required to confirm this observation. Regional nerve block is associated with lower risk, and when possible, should be considered for high-risk patients. As an example, an axillary block with conscious sedation could be used for an upper-extremity procedure.[15,16]

Type of neuromuscular blockade

The use of a long-acting neuromuscular blocker leads to a higher incidence of postoperative residual neuromuscular blockade than shorter-acting agents, and a higher incidence of postoperative pulmonary complications in those patients with residual neuromuscular blockade.[17] Residual neuromuscular blockade is also an important risk factor for critical respiratory events in the immediate postoperative period.[18]

Preoperative clinical evaluation

A thorough history and physical examination are the most important aspects of preoperative pulmonary risk assessment. In particular, the clinician should investigate a history of exercise intolerance, chronic cough, or unexplained dyspnoea. Even subtle symptoms can be relevant in risk identification, and should alert the clinician to a need for more detailed investigation.

Physical examination may identify findings suggestive of unrecognised pulmonary disease.

Among such findings, the following predict an increase in the risk of pulmonary complications:[8]
- Decreased breath sounds
- Dullness on percussion
- Wheezing
- Rhonchi
- Prolonged expiratory phase.

Preoperative pulmonary function testing

Routine preoperative pulmonary function testing (PFT) in non-thoracic surgery is not generally supported, and is best performed selectively in patients with clinical evidence of underlying pulmonary risk. There is considerable debate regarding the role of preoperative PFT for risk stratification. In most cases, these tests simply confirm the clinical impression of disease severity, adding little to the clinical estimation of risk. Concern has been raised that preoperative PFT is used excessively, and contributes to wasting of healthcare funds.[18-20]

Two reasonable goals that could potentially justify the use of preoperative PFT are identification of a group of patients for whom the risk of the proposed surgery is not justified by the benefit, and identification of a subset of patients at higher risk, for whom aggressive perioperative management is warranted.[20]

A number of pulmonary function measures have been evaluated. Bedside spirometry is widely available, and measures of the forced expiratory volume in one second (FEV1), and forced vital capacity (FVC), have been frequently reported. Early reviews suggest criteria for increased risk, which include FEV1 < 70% predicted, FVC < 70% predicted, and FEV1:FVC ratio < 65%.[21]

From the literature, little support is available that either of the proposed goals is routinely met, other than for lung resection surgery. As an example, in a study of patients with severe COPD (FEV1 < 50%), preoperative PFTs did not predict the risk of pulmonary complications, whereas length of surgery, ASA class and type of procedure were all significant predictors.[21]

Two well-designed case control studies have evaluated the benefit of PFTs as risk predictors. In a study of patients undergoing abdominal surgery, no difference in FEV1, FVC or FEV1:FVC was noted between patients with, and without, a pulmonary complication.[18] In contrast, physical examination factors predicted risk.[22]

Based on a systematic review, a 2006 American College of Physicians' guideline recommended that clinicians should not use preoperative spirometry routinely to predict the risk of postoperative pulmonary complications.[21,23]

A reasonable approach to patient selection for preoperative pulmonary function testing includes the following:

- Obtain PFTs for patients with COPD or asthma, if the clinical evaluation cannot determine whether the patient is at his or her best baseline, and that airflow obstruction is optimally reduced. In these cases, PFTs may identify patients who will benefit from more aggressive preoperative management.
- Obtain PFTs for patients with dyspnoea or exercise intolerance that remains unexplained after clinical evaluation. In these cases, differential diagnosis may include cardiac disease or deconditioning. The results of PFTs may change preoperative management.
- PFTs should not be used as the primary factor to deny surgery.
- PFTs should not be ordered routinely prior to abdominal surgery, or other high-risk surgeries.

Arterial blood gas analysis

No data suggest that the finding of hypercapnia identifies high-risk patients who would not have otherwise been identified, based upon established clinical risk factors. In a small prospective cross-sectional case series, a high risk of postoperative pulmonary complications among patients with a $PaCO_2$ > 45 mmHg has been suggested, a finding usually seen only in patients with severe chronic obstructive lung disease.[24] The risk associated with this degree of $PaCO_2$ elevation is not necessarily prohibitive, although it should lead to a reassessment of the indication for the proposed procedure, and aggressive preoperative preparation. Hypoxaemia has generally not been identified as a significant independent predictor of complications after adjustment for potential confounders.[24] Current data do not support the use of preoperative arterial blood gas analyses to stratify the risk of postoperative pulmonary complications.

Chest radiographs

Chest X-rays add little to the clinical evaluation in identifying healthy patients at risk of perioperative complications. A meta-analysis of studies on routine preoperative chest X-rays demonstrated a low yield of abnormalities that actually change preoperative management.[22,25] Among 14 390 preoperative X-rays, 140 unexpected abnormalities were found, and in only 14 of these cases, the abnormalities influenced management of the patient.[25]

The available literature does not allow an evidence-based determination of which patients will benefit from a preoperative chest X-ray. However, it is reasonable to obtain preoperative chest X-rays in patients with known cardiopulmonary disease, and in those who are older than 50 years of age undergoing high-risk surgical procedures, including upper abdominal, aortic, oesophageal, and thoracic surgery.

Exercise testing

Exercise testing has been studied extensively in preparation for lung resection surgery.[26] However, no data are available that support its routine use in the evaluation of patients prior to general surgery.

Pulmonary risk indices

Three proposed pulmonary risk indices, not discussed in detail in this review, are a combined Cardiopulmonary Risk Index, the Brooks-Brunn Risk Index, and a multifactorial risk index for postoperative respiratory failure.[26-29]

Risk reduction strategies

Preoperative strategies

- Encourage cessation of cigarette smoking for at least eight weeks.
- Treat airflow obstruction in patients with COPD or asthma.
- Administer antibiotics, and delay surgery if respiratory infection is present.
- Begin patient education regarding lung expansion manoeuvres.

Intraoperative strategies

- Attempt to limit duration of surgery to less than three hours.
- Use spinal or epidural anaesthesia.
- Avoid the use of pancuronium.
- When possible, use laparoscopic procedures.
- When possible, substitute to less ambitious procedure for upper abdominal or thoracic surgery.

Postoperative strategies

- Use deep-breathing exercises.
- Use continuous positive airway pressure.
- Use epidural analgesia.
- Use intercostals nerve blocks.[16]

Conclusion

Postoperative pulmonary complications occur more frequently than cardiac complications, are more costly to manage, and result in longer hospital stays. Generally, greater emphasis on respiratory risk identification is required in surgery. Subtle findings in the patient's medical history can be important indicators of underlying risk.

Careful acquisition of the patient's history, and a thorough physical examination, are the most important tools for preoperative risk assessment of patients for potential postoperative pulmonary complications. Attention should focus on symptoms suggesting the possibility of occult underlying lung disease, including exercise intolerance, cough, and unexplained dyspnoea. In addition to the patient's history and physical examination, a number of selected special investigations may provide additional information to identify patients at higher risk of surgery-related pulmonary complications.

Acknowledgements

Professor Anthony Linegar is kindly acknowledged for his assistance in preparing this manuscript.

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