Pre- and intra-operative management of the patient for thoracic anaesthesia, teamwork

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This review will focus on patients for pulmonary resection surgery but the general principles apply to patients with pulmonary disease having any intra-thoracic surgical procedure. An evidence-based strategy will be developed to allow the anaesthesiologist to stratify patients according to their risk of perioperative complications and also to direct anesthetic management to modify the risk. To assess the patients preoperatively it is necessary to have an understanding of the risks specific to this type of surgery (1). The major cause of perioperative morbidity and mortality in the thoracic surgical population is respiratory complications. For other types of surgery, cardiac and vascular complications are the leading cause of early perioperative morbidity and mortality.

The best assessment of respiratory function comes from a history of the patient's quality of life (2). It is useful to have objective measures of pulmonary function that can be used to guide anaesthetic management and to have this information in a format that can be easily transmitted between members of the health care team. There are many factors that determine overall respiratory performance (3). It is useful to think of the respiratory function in three related but somewhat independent areas: respiratory mechanics, gas exchange, and cardio-respiratory interaction.

1) Respiratory mechanics:
Many tests of respiratory mechanics and volumes show correlation with post-thoracotomy outcome. It is useful to express these as a percent of predicted volumes corrected for age, sex and height (e.g.: FEV1 %). Of these, the most valid single test for post-thoracotomy respiratory complications is the predicted postoperative forced expiratory volume in one second (ppoFEV1 %) calculated as (4):
ppoFEV1 % = preoperative FEV1 % x (1- % functional lung tissue removed/100).
A study from the 1980's found that patients with a ppoFEV1 >40% had no or minor post-resection respiratory complications. Major respiratory complications were only seen in the subgroup with ppoFEV1 <40% and patients with ppoFEV1 <30% required postoperative mechanical ventilatory support (5). The use of epidural analgesia has decreased the incidence of complications in the high-risk group (6).

2) Lung parenchymal function:
Arterial blood gas data such as PaO_2 <60 mmHg or $PaCO_2$ >45 mmHg have been used as cut-off values for pulmonary resection. Cancer resections have now been successfully done or even combined with volume reduction in patients who do not meet these criteria (7). The most useful test of the gas exchange capacity of the lung is the diffusing capacity for carbon monoxide (DLCO) (8). The DLCO correlates with the total functioning surface area of alveolar-capillary interface. The DLCO can be used to calculate a post-resection (ppo) value using the same calculation as for the FEV1. A ppoDLCO <40% predicted correlates with both increased respiratory and cardiac complications and is relatively independent of the FEV1 (9).

3) Cardio-pulmonary interaction:
The most important assessment of respiratory function is an assessment of the cardio-pulmonary interaction. The traditional test is stair climbing (10). The ability to climb 3 flights or more is closely associated with decreased mortality and morbidity. Less than 2 flights is very high risk. Formal laboratory exercise testing with maximal oxygen consumption (VO_2max) is the "gold standard" for assessment of cardio-pulmonary function. Climbing 5 flights of stairs approximates a VO_2max of >20ml/kg/min and less than one flight a VO_2max <10ml/kg/min (11). In a high-risk group of patients (mean pre-operative FEV1= 41% predicted) there was no perioperative mortality if the preoperative VO_2max was >15ml/kg/min (12). Alternatives to VO_2max include the six-minute walk test (6MWT) (13) and exercise oximetry (14). For patients with moderate to severe COPD the 6MWT has a high correlation with VO_2max, which can be estimated from the distance in meters/30 (i.e. for a 6MWT distance of 450m, VO_2max = 450/30= 15 ml/kg/min) (15).

4) Ventilation perfusion (V/Q) scintigraphy:
Prediction of post-resection pulmonary function can be further refined by assessment of the pre-operative contribution of the lung or lobe to be resected using V/Q lung scanning (16). If the lung region to be resected is non- or minimally functioning the prediction of post-operative function can be modified accordingly. This is particularly useful in pneumonectomy patients and should be considered for any patient who has a ppoFEV1 <40%. Other tests of pulmonary function such as split-lung function studies and flow-volume loops have not shown sufficient predictive validity for widespread universal adoption in potential lung resection patients.

5) Combination of tests:
No single test of respiratory function has shown adequate validity as a sole pre-operative assessment. Prior to surgery an estimate of respiratory function in all 3 areas: lung mechanics, parenchymal function and cardio-pulmonary interaction should be made for each patient. If a patient has a ppoFEV1 >40% it should be possible for that patient to be extubated in the operating room at the conclusion of surgery assuming the patient is alert, warm and comfortable ("AWaC"). If the ppoFEV1 is >30% and exercise tolerance and lung parenchymal function exceed the increased risk thresholds then extubation in the operating room may be possible depending on the status of associated diseases (see below). Those patients in this subgroup who do not meet the minimal criteria for cardio-pulmonary and parenchymal function should be considered for staged weaning from mechanical ventilation post-operatively so that the effect of the increased oxygen consumption of spontaneous ventilation can be assessed. Patients with a ppoFEV1 20-30% and favorable predicted cardio-respiratory and parenchymal function can be considered for early extubation if thoracic epidural analgesia if used. The validity of this approach has been confirmed by the National Emphysema Treatment Trial which found an unacceptably high mortality for lung volume reduction surgery in patients with preoperative FEV1 and DL-CO values <20% predicted (17).

Inter-current medical conditions

1) Reactive airways disease:
Broncho-constriction is assessed by history, physical examination and evaluation of pulmonary function response to bronchodilators. All COPD patients should receive maximal bronchodilator therapy as guided by their symptoms. In a patient who is poorly controlled on sympathomimetic and anticholinergic bronchodilators, a trial of corticosteroids may be beneficial (18). It is not clear if corticosteroids are as beneficial in COPD as they are in asthma.
Is referral to a Chest Physician indicated? The Anaesthesiologist will have to decide if the patient with reactive airways disease is adequately managed preoperatively, i.e. func-

tionally at his/her usual level of exercise tolerance and with flow-rates >80% of stable baseline. If preoperative management of bronchospasm is inadequate or if there is any evidence of current respiratory infection, the patient should be referred to a Chest or Family Physician for therapy preoperatively.

With advances in anaesthetic management the incidence of life-threatening intra-operative bronchospasm has become very low (19). However, the anaesthesiologist must always respect the management principles for patients with reactive airways: preoperative optimization of bronchodilation, minimal (or no) instrumentation of the airways, instrument the airways only after appropriate depth of anaesthesia with a bronchodilating anaesthetic (Propofol, Ketamine, Sevoflurane), and maintenance of anaesthesia with a bronchodilating anaesthetic and appropriate warming and humidification of inspired gases (20). In patients with bronchial hyper-reactivity (FEV1 <70% and >10% increase with bronchodilator) on regular bronchodilator therapy, post-intubation wheezing can be significantly reduced by addition of a 5-day pre-operative course of corticosteroids (methyl-prednisolone 40mg/day p.o.) (21).

2) Age:

If a patient is 80 years of age and has a stage I lung cancer, their chances of survival to age 85 are better with the tumor resected than without (22). However, the rate of respiratory complications (40%) is double that expected in a younger population and the rate of cardiac complications (40%), particularly arrhythmias, triple that which should be seen in younger patients. Although the mortality from lobectomy in the elderly is acceptable, the mortality from pneumonectomy (22% in patients >70 years) (23), particularly right pneumonectomy, is excessive. Pulmonary resection in the elderly should be regarded as a high-risk procedure for cardiac complications and cardiopulmonary reserve is the most important predictor of outcome in this population (24).

3) Cardiac disease:

Cardiac complications are the second most common cause of peri-operative morbidity and mortality in the thoracic surgical population.

a) Ischaemia: the majority of pulmonary resection patients have a smoking history and already have one risk factor for coronary artery disease (25). Pulmonary resection surgery is an "intermediate risk" procedure in terms of peri-operative cardiac ischaemia (26). Non-invasive testing is indicated in patients with major (unstable ischaemia, recent infarction, severe valvular disease, significant arrhythmia) or intermediate (stable angina, remote infarction, previous congestive failure, or diabetes) clinical predictors of myocardial risk and also in the elderly.

b) Arrhythmia: Dysrhythmias, particularly atrial fibrillation, are a frequent complication of pulmonary resection surgery (27). Factors known to correlate with an increased incidence of arrhythmia are the amount of lung tissue resected, age, intra-operative blood loss, and intra-pericardial dissection (28). Prophylactic therapy with digoxin has not been shown to prevent these arrhythmias. Diltiazem has been shown to be effective (29).

4) Renal dysfunction:

Renal dysfunction following pulmonary resection surgery is associated with a very high incidence of mortality (19%) (30). The factors which are associated with an elevated risk of renal impairment are: history of previous renal dysfunction, diuretic therapy, pneumonectomy, postoperative infection and transfusion.

Physiotherapy

Patients with COPD have fewer post-operative pulmonary complications when a programme of chest physiotherapy is initiated preoperatively (31). Among COPD patients, those with excessive sputum benefit the

most from chest physiotherapy (32). A comprehensive programme of pulmonary rehabilitation involving physiotherapy, exercise, nutrition and education has been shown to consistently improve functional capacity for patients with severe COPD (33). Atelectasis in the post-operative period leads to increased capillary permeability and an inflammatory response with subsequent lung injury. If it persists (34) it should be treated with aggressive physiotherapy (35).

Lung cancer

At the time of initial assessment cancer patients should be assessed for the "4-M's" associated with malignancy: mass effects (36), metabolic abnormalities, metastases (37) and medications. The prior use of medications which can exacerbate oxygen induced pulmonary toxicity such as bleomycin should be considered (38). Recently we have seen several lung cancer patients who received preoperative chemotherapy with cis-platinum and then developed an elevation of serum creatinine when they received non-steroidal anti-inflammatory analgesics (NSAIDS) postoperatively. For this reason we now do not routinely administer NSAIDS to patients who have been treated recently with cis-platinum.

Smoking cessation

In non-pulmonary surgery a pre-operative smoking cessation programme can significantly decrease the incidence of respiratory complications (8 weeks abstinence), wound complications (4 weeks abstinence) and intra-operative myocardial ischaemia (48 hr. abstinence) (39). However in thoracic surgical patients, pulmonary complications are decreased in those who are not smoking versus those who continue to smoke up until the time of surgery (40). The perioperative period is a specific stimulus for patients to stop smoking, 55% patients were found to remain abstinent from smoking one-year after aorto-

coronary bypass, versus only 25% 1 year after angioplasty and 14% after angiography and physician counselling is a major part of the stimulus (41). Smoking cessation can be achieved in >50% of perioperative patients with a structured program and can result in an overall decrease of complications of >50% (42).

Perioperative surgical environment factors

There are multiple factors in the surgical environment that can contribute to lung injury in this patient. One of the most obvious is the surgical approach. If these procedures can be done with a minimally invasive technique vs. an open laparotomy the decrease in respiratory complications is well documented (43).

Atelectasis: Atelectasis is a frequent post-operative complication of open surgical procedures. Atelectasis occurs intra-operatively as part of essentially any general anaesthetic (44). Anaesthesiologists are aware of this and techniques to avoid it with use of air oxygen mixtures, PEEP and recruitment manoeuvres are used frequently (45). However, anaesthesiologists are often not aware that atelectasis is a pathological state, and in the post-operative period leads to increased capillary permeability and an inflammatory response with subsequent lung injury if it persists (46). Both retrospective (47) and prospective (48) studies have consistently shown that appropriate thoracic epidural analgesia reduces the incidence of respiratory complications (atelectasis, pneumonia and respiratory failure) after major abdominal and thoracic surgery. It has also been recently demonstrated that aggressive physiotherapy with CPAP in the post-operative period in patients who develop early desaturation after major abdominal surgery leads to lower rates of major respiratory complications (49).

Postoperative analgesia

The strategy for postoperative analgesia should be developed and discussed with the patient during the initial preoperative assessment. Only epidural techniques have been shown to consistently decrease post-thoracotomy respiratory complications (50, 51). Thoracic epidural analgesia is superior to lumbar epidural analgesia due to the synergy which local anaesthetics have with opioids in producing neuraxial analgesia. Studies suggest that epidural local anaesthetics increase segmental bio-availability of opioids in the cerebrospinal fluid (52) and increase the binding of opioids by spinal cord receptors (53). Only the segmental effects of thoracic epidural local anaesthetic and opioid combinations can reliably produce increased analgesia with movement and increased respiratory function following a chest incision (54). In patients with coronary artery disease, thoracic epidural local anaesthetics reduce myocardial oxygen demand and supply in proportion (55), unlike lumbar epidural local anaesthetics (56). Thoracic epidural analgesia has been shown to be associated with a decreased risk of requiring post-operative ventilatory support (57).

At the time of initial pre-anaesthetic assessment the risks and benefits of the various forms of post-thoracotomy analgesia should be explained to the patient. Potential contraindications to specific methods of analgesia should be determined such as coagulation problems, sepsis or neurologic disorders. When it is not possible to place a thoracic epidural due to concerns with patient consent or other contraindications, our current second choice for analgesia is a paravertebral infusion of local anaesthetic via a catheter placed intraoperatively in the open hemithorax by the surgeonl (58). This is combined with intravenous patient-controlled opioid analgesia and NSAIDS.

If the patient is to receive prophylactic anticoagulants and it is elected to use epidural analgesia, appropriate timing of anticoagulant administration and neuraxial catheter placement need to be arranged. ASRA guidelines suggest an interval of 2-4 hours before or one hour after catheter placement for prophylactic heparin administration (59). Low molecular weight heparin (LMWH) precautions are less clear, an interval of 12-24 hours before and 24 hours after catheter placement are recommended.

Summary

Recent advances in anaesthetic care have improved outcomes for patients with respiratory disease having major surgery. Understanding and stratifying the perioperative risks allows the anaesthesiologist to develop a systematic focused approach to these patients, which can then be used to both assess and manage these patients.

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