Anesthetic considerations in patients with chronic pulmonary diseases

D. HENZLER, R. DEMBINSKI, R. KUHLEN, R. ROSSAINT

**Aim.** Increasing age and co-morbidities of patients admitted for surgery impose new challenges on the anesthesiologist.

**Methods.** Review of current literature regarding the perioperative management of patients with chronic pulmonary disease.

**Results.** If patients are treated adequately, surgery can be safely performed under regional and general anaesthesia. Major risk factors include type of surgery, type and duration of anesthesia, general health status and smoking history, but not certain lung function parameters. Regional anesthesia remains the first choice for intra- and postoperative care, and if general anesthesia is necessary, early extubation should be achieved. Non-invasive ventilation could be a possible alternative in weaning failure.

**Conclusion.** Assessing the functional status of patients admitted to surgery remains a difficult task, and in patients identified at risk by clinical examination additional spirometry and blood gases may be helpful. If there are signs of respiratory failure, the anesthetist should monitor the patient closely and invasively, yet there is no reason to deny any patient a substantially beneficial operation.

Key words: Pulmonary disease, chronic obstructive - Intraoperative complications - Perioperative care - Postoperative care-anaesthesia, conduction

Anesthesiologists are increasingly confronted with patients admitted for elective and emergency surgery, who present with more co-morbidities than those considered to be inoperable only a few years ago. Especially chronic pulmonary disease has developed to a major burden of civilization with increasing prevalence. Expressed as disability adjusted life years (DALY) lost, which is the sum of years lost due to severe disability and premature mortality, chronic pulmonary disease has ranked 12th in 1990 and is predicted to rank 5th in 2020 of all diseases world-wide. Constant advances in anesthetic techniques have shown that safe conduction of anesthesia is possible under a variety of pathologic conditions, and this has led to abandon classical contraindications against anesthesia, for example a certain lung function parameter. This article presents a review on recent published studies and recommendations for practical use.

**Preoperative risk assessment and preparation**

For safe conduction of anesthesia it is necessary to assess the risk for perioperative
complications given the specific disease and operation, the method of choice for anesthetic technique and the specific advantages/risks for certain surgical procedures (e.g., minimal invasive techniques). Therefore, subtle questioning and a thorough clinical examination should stand before performing any anesthetic procedure. Common symptoms and clinical findings with the concordant diagnosis are summarised in Table I.

In the absence of clear cut guidelines the American Society of Anesthesiologists (ASA) has conducted a survey on preoperative lung function testing4, which showed that routine testing for all patients was not considered, but 98% of anesthesiologists ordered lung function tests in specific patients. Of these, in 68% asthma, 80% COPD and 53% significant scoliosis were present. Still the Task Force believed that "there is insufficient evidence to identify explicit decision parameters or rules for ordering preoperative tests on the basis of specific clinical characteristics...". A review on preoperative evaluation of lung function was given previously5, which did not reveal specific parameters of lung function predictive of postoperative complications. Just the existence of COPD incorporated an increased risk, as it would be represented in general assessment scores, like the ASA physical health score, anyway. The highest predictive parameter was upper abdominal or thoracic surgery. Fisher et al.5,6 have done a systematic review on blinded studies, but of a total of 16 singular parameters reported (one of them COPD), only duration of anesthesia and postoperative placement of a nasogastric tube were independently associated with increased risk of postoperative pulmonary complications. Arozullah et al.7,8 have published the largest single study investigating a newly developed risk index for postoperative respiratory failure (181 109 patients) or postoperative pneumonia (316 071 patients) in non-thoracic surgery. COPD was a major predictor of complications in both studies (respiratory failure: RR(CI) 1.81(1.66-1.98); pneumonia 1.72(1.55-1.91), but was outweighed by far from type of surgery (upper abdominal: respiratory failure: 4.21(3.8-4.67); pneumonia 4.29(3.34-5.5). Unfortunately, no risk adjustment had been calculated for COPD, and no spirometry data had been evaluated. More concise data is reported from a very recent series of 272 patients undergoing non-cardiothoracic surgery9. Clinical preoperative assessment and postoperative complications were collected independently and analysed for predictors. Besides age >65 and history of >40 pack years of smoking, COPD, asthma, productive cough and exercise intolerance of less than 1 flight of stairs was associated with significantly increased risk of postoperative pulmonary complications. More interestingly, physical examination with symptoms of airflow obstruction [e.g. expiratory time ≥ 9 sec.: OR 5.7 (2.3-14.2)] were strong predictors, but type of surgery were not. Reduced FEV 1 (7.9(1.7-37)), hypercarbia 61 (3.8-986) and hypoxia 13.4 (1.3-14.1) also indicated precisely the occurrence of postoperative pulmonary complications. A summary of risk factors is given in Table II.

The role of nicotine cessation before anesthesia in reducing pulmonary complications has been investigated by Warner et al.10,11, showing an increased complication rate if patients quit smoking for less that 8 weeks before operation, but less complications if they quit smoking for more that 8 weeks as compared to active smokers. Lung exercise of several weeks can be effective in increasing

| Table I. — Clinical symptoms of chronic pulmonary diseases. |
|---------------------------------|-----------------|
| Symptom                         | Clinical correlate                               |
| Orthopnoea, dyspnoea            | Pulmonary and cardiac impairment COPD            |
| “happy wheezer”, “pink puffer”  | COPD                                          |
| Cyanosis                        | Right-left shunt, severe restriction             |
| “barrel chest”, decreased breath sounds | Emphysema                                |
| Prolonged expiration, wheeze    | Asthma                                        |
| Rough breath sounds             | Pulmonary oedema, pneumonia, secretion retention |
| Fine cracksels                  | Pneumonia, atelectasis, fibrosis                |
| Friction sounds                 | Pleuritis                                      |
| Inspiratory stridor            | Interstitial oedema                             |
| Expiratory stridor             | COPD, asthma                                   |

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**Table II.** Risk factors for postoperative pulmonary complications

<table>
<thead>
<tr>
<th>Patient dependent factors</th>
<th>Surgery dependent factors</th>
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<tbody>
<tr>
<td>Current smoker</td>
<td>Abdominal surgery</td>
</tr>
<tr>
<td>Reduced health status (ASA grade &gt;2)</td>
<td>Thoracic surgery</td>
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<tr>
<td>Old age (&gt;70 years in pts. with COPD)</td>
<td>Long duration of surgery (&gt;3h)</td>
</tr>
<tr>
<td>COPD with exercise intolerance</td>
<td>General anesthesia (vs. regional anesthesia)</td>
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lungs function\(^{12}\), and those patients without postoperative pulmonary complications exhibited improvements in lung function, while those with complications were unresponsive to exercises.

Oral premedication on the ward should be cautioned, since benzodiazepines have shown to reduce respiratory strength\(^{13}\). In patients with borderline respiratory function, this might just be enough to cause decompen-sation, and i.v. premedication in the operating theatre just before induction should be considered instead.

**Intraoperative management**

During general anesthesia, patients with pulmonary disease are threatened by various unphysiologic conditions. Supine position and positive pressure ventilation can ham-per borderline respiratory function by a reduction in FRC and an increase in atelectasis\(^ {11}\). This can be reversed in part by application of PEEP\(^ {15}\), which per se is not con-traindicated in patients with COPD. Especially in COPD patients potential dynamic hyper-inflation can lead to life-threatening hypotension\(^ {16}\) and should first be treated by disconnecting the patient from the ventilator\(^ {17}\). Dynamic hyperinflation can easily be detected by measurement of intrinsic PEEP (PEEPi) by endexpiratory occlusion. PEEPi is the difference of alveolar to ventilator airway expiratory pressure (external PEEP). From simple mathematical calculation, PEEPi can be reduced by increasing external PEEP. Importantly, this does not reduce hyperinflation, which can be done only by prolon-gation of expiratory time\(^ {18}\) or reversal of bronchoconstriction, and external PEEP should be set below PEEPi.

General anaesthesia has been associated with increased risk for bronchoconstriction and postoperative complications, although there really is no data to support this view. Usually, general anaesthesia can be applied safely\(^ {2,19}\). Volatile anaesthetics are even used for rescue therapy in very severe status asthmaticus, due to their bronchodilative properties\(^ {20}\). However, induction of anaesthesia should be undertaken with caution, since histamin liberating induction agents, light anaesthesia and mechanical irritation can induce bronchoconstriction. If problems are going to be anticipated, for example in asthmatic children or in awake fiberoptic intubation, pre-treatment with salbutamol might prevent deleterious complications\(^ {21,22}\). The addition of lignocaine might be able to enhance the effect. Most modern sedatives and opioids\(^ {23}\) can be used safely, even though all (including propofol)\(^ {24,25}\) have the potential to trigger bronchoconstriction. However, it must be stressed that deep anaesthesia still is a major prophylactic against bronchoconstriction, in healthy as well as COPD patients.

Theoretically, the avoidance of mechanical irritation of the trachea by usage of a laryngeal mask (LMA) might improve lung function. It was indeed demonstrated in healthy patients\(^ {26}\) that FEV\(_1\), FVC and peak expiratory flow (PEF) postoperatively were higher, if a LMA was used. To reproduce these results in lung diseased patients remains an interesting task for future investigations.

In contrast to general anesthesia, regional anaesthesia has the advantage of otherwise unimpaired lung function. However, patients are often unable to lie strictly supine or get progressively uncooperative with worsening hypoxia. Vanek \textit{et al.}\(^ {27}\) have reported a series of 10 patients having undergone off-pump CABG in high thoracic epidural anaesthesia (TEA) without intubation. Another three patients with partial respiratory failure and FEV\(_1\) <50% predicted had open infrarenal
aortic aneurysm repair done in combined spinal and epidural anaesthesia (CSE), breathing spontaneously, without adverse events\textsuperscript{28}. However, most researchers have focussed on the advantages of combining general with epidural anaesthesia. Postoperative pain, especially after thoracic surgery, is a main cause of decreased vital capacity (VC), resulting in hypoventilation, formation of atelectasis and pneumonia. Various studies have shown the beneficial effects of TEA on postoperative pain management, restoration of lung function and accelerated recovery in thoracic and upper abdominal surgery. Also, neural sympathetic blockade was effective in decreasing the rate of postoperative cardiac complications in patients with coronary artery disease. There is some concern, whether TEA by respiratory motor blockade causes a decrease in peak airflow rates, expiratory reserve volume and vital capacity\textsuperscript{29,30}. In contrast, Groeben \textit{et al}.\textsuperscript{31} could demonstrate in COPD patients receiving TEA with ropivacaine or bupivacaine that there was a significant decrease in VC and FEV1 of up to 23% just by changing position from sitting to supine, and a further decrease of up to 16% with onset of TEA. Since complete sensory blockade was achieved, the following breast surgery could be carried out with only additional light sedation. Much lower concentrations of bupivacaine (0.25%) were used by Gruber \textit{et al}.\textsuperscript{32}, in a cohort of 12 patients receiving TEA before lung volume reduction. These exhibited in contrast to the previous study an increase in tidal volume, a decrease in airway resistance and subsequent increase in peak inspiratory flow rate. The differences between the studies can be explained by local anesthetic concentration and body position, which was maintained upright in the latter study. It was previously shown that neural sympathetic blockade does not induce bronchoconstriction, because the bronchial motor tone is preferentially determined by $\beta_2$-adrenergic stimulation rather than the parasympathetic/sympathetic autonomous balance. In conclusion of these results, TEA seems safe for postoperative pain management, and can even be sufficient for singular use in certain operations. Body position has great influence on lung function, and a strictly supine position should be avoided in spontaneously breathing patients with chronic pulmonary disease. However, no study so far independently from confounding parameters investigated outcome from certain operations if performed under regional or general anaesthesia in patients with lung disease.

In any case, close monitoring including invasive blood pressure measurements and repeated blood gas analysis should be applied to avoid hypoxemia. Especially patients with pulmonary hypotension and cor pulmonale are prone to acute right heart decompensation in hypoxemia and pulmonary vasodilators should be considered in severe cases\textsuperscript{33}.

**Postoperative care**

Effective pain control postoperatively is most crucial in patients with pulmonary disease, since these are especially prone to pulmonary complications induced by pain-related hypoventilation. Regional analgesia, specifically administered by epidural analgesia, has been shown to reduce atelectasis formation (RR 0.53, 0.33-0.85 95\%CI) and incidence of pulmonary infection (RR 0.58, 0.42-0.8 95\%CI) as compared to systemic opiate analgesia\textsuperscript{34}. Early extubation should be targeted for, as overall ICU mortality in patients needing >12 hours of mechanical ventilation has been shown to be as high as 31\%\textsuperscript{35}, of which 11\% presented with chronic pulmonary disease. Mortality of those admitted postoperatively (21\% of all patients) was lower (22\%) than overall mortality (OR 0.67, 0.59-0.76 95\%CI) and was equal to those with COPD (22\%). Even if partial respiratory failure persists, early extubation followed by non-invasive ventilation (NIV) could be beneficial. However, so far only medical patients have been evaluated in randomised trials. Ferrer \textit{et al}.\textsuperscript{36} have reported shorter mechanical ventilation and length of stay, lower incidence of complications and improved survival in patients with weaning failure if NIV was used as com-
pared to conventional weaning approach. This was confirmed by a meta-analysis, showing a positive effect of NIV as a weaning strategy on survival in patients with respiratory failure, most of whom had COPD.

Conclusions

Assessing the functional status of patients admitted to surgery remains a difficult task, and in patients identified at risk by clinical examination additional spirometry and blood gases may be helpful. Still it is hard to predict, whether the patients condition could be improved, which has to rely on the adequacy of current treatment. Function tests like stair-climbing or the ATS 6-minute-walk-test have been proposed, but they lack data of association of a given value with a specific outcome. If there is flow limitation and signs of respiratory failure, the anesthetist should be highly alarmed and monitor the patient closely and invasively, yet there is no reason to deny any patient a substantial beneficial operation. If it is possible, regional anesthesia with preserved spontaneous breathing should be applied. Intubation has also proven to be safe, but fast extubation should be the aim like in any of our patients. The other striking perception is that non-invasive ventilation as a weaning strategy can be effective in improving outcome in patients with chronic pulmonary disease, if the airways can be protected and cleared adequately. The validation for patients with postoperative respiratory failure however has yet to be done in future research.

Riassunto
Considerazioni di natura anestesiologica nei pazienti affetti da patologie polmonari croniche

Obiettivo. L’aumento dell’età e del numero di patologie in comorbilità nei pazienti ricoverati per essere sottoposti a un intervento chirurgico pone nuove sfide per l’anestesista.

Metodi. È stata condotta una review aggiornata della letteratura medica riguardante il trattamento perioperatorio dei pazienti affetti da patologia polmonare cronica.

Risultati. Se i pazienti sono adeguatamente trattati, l’intervento chirurgico può essere eseguito in condizioni di sicurezza sotto anestesia regionale e generale. I principali fattori di rischio comprendono il tipo di intervento chirurgico, il tipo e la durata dell’anestesia, lo stato generale di salute e l’anamnesi posiziva per fumo, ma non certi parametri di funzionalità respiratoria. L’anestesia regionale costituisce tuttora la prima scelta durante l’intervento chirurgico e nel periodo postoperatorio, e qualora sia necessaria l’anestesia generale, bisogna procedere con l’estubazione precoce. La ventilazione non invasiva potrebbe rappresentare una valida alternativa in caso di mancato svezzamento.

Conclusioni. La valutazione dello stato funzionale dei pazienti ricoverati per intervento chirurgico rimane un obiettivo di difficile realizzazione; nei pazienti identificati a rischio sulla base dell’esame clinico si possono rilevare utili una spirometria aggiuntiva e un’emogasanalisi. Se ci sono segni di insufficiente respiratoria, l’anestesista deve monitorare attentamente e in modo invasivo il paziente, tuttavia non c’è ragione di impedire al paziente di sottoporsi a un intervento chirurgico in grado di procurare importanti benefici.

Parole chiave: Broncopneumopatia cronica ostruttiva - Complicanze operatorie - Trattamento perioperatorio - Trattamento postoperatorio - Anestesia regionale.

References
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