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Anaesthesia and Postoperative Analgesia in Older Patients with Chronic Obstructive Pulmonary Disease

Special Considerations

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Abstract

Chronic obstructive pulmonary disease (COPD) and older age are known to be independent risk factors for severe perioperative adverse outcomes after surgery. A basic understanding of the disease, careful preoperative evaluation and preparation of the patient, as well as a tailored anaesthetic management plan might help to decrease complications in this patient population.

Aging affects the pharmacokinetics and pharmacodynamics of almost all drugs and therefore the dosage must be adapted in older patients. The type of anaesthesia (general versus regional anaesthesia) has no substantial effect on perioperative morbidity and mortality. Most patients, even with severe COPD, tolerate general

anaesthesia without major problems. One important goal of the anaesthetic management is to prevent reflex-induced bronchoconstriction, which can be accomplished by the use of volatile anaesthetics. Early recovery can be facilitated by the use of short-acting drugs, such as propofol and the new opioid remifentanil. Judicious use of neuromuscular blocking agents is necessary because of the risk of residual paralysis, and those agents associated with histamine liberation should be avoided. Ventilation requires long expiration times to avoid air trapping, and hyperinflation to avoid the possible threat of pneumothorax and a decrease in cardiac output.

For postoperative analgesia, a balanced regimen consisting of regional analgesia with local anaesthetics and NSAIDs should be preferred. This will enhance analgesia and reduce opioid toxicity, which is important in patients with COPD, where respiratory depression is especially dangerous.

Chronic obstructive pulmonary disease (COPD) and older age are known to be independent risk factors for severe perioperative adverse outcomes after surgery.[1] A recent study indicated that during 2000, 10 million US adults had physician-diagnosed COPD and approximately 24 million adults had evidence of impaired lung function.[2] Very likely, similar data will apply for most parts of the world. Therefore, COPD is a frequent comorbidity in patients presenting for all kinds of surgery.

COPD includes three disorders, namely emphysema, peripheral airway disease and chronic bronchitis. A patient may have one or more of these conditions. Emphysema is associated with a decrease in elastic recoil of lung tissue, resulting in decreased maximum expiratory air flow, which leads to air trapping, hyperinflation and severely limited exercise capacity.[3] In addition, the destruction of the alveolar-capillary membrane surface leads to a reduction in diffusing capacity. The primary cause of emphysema is cigarette smoking, but in addition, occupational or environmental exposures and genetic factors (e.g. α1-antitrypsin deficiency) may cause the disease.[4]

The diagnosis of COPD is confirmed by spirometry. The hallmarks of COPD are a reduction in forced expiratory volume in 1 second (FEV_1), a reduction in the ratio of FEV_1 to forced vital capacity (FVC) compared with standard reference values, and less than 12% improvement after challenge with an inhaled bronchodilator.[5]

The postoperative mortality rate is increased 10-fold in patients with COPD compared with patients without pulmonary disease.[6] Several factors related to anaesthesia and surgery seem to especially endanger patients with COPD:

- anaesthetics and analgesics used during the perioperative period may alter the bronchial tone, the central regulation of breathing and change the neural drive to respiratory muscles such as the diaphragm;
- positioning of the patient and mechanical ventilation induce alterations in respiratory mechanics and gas exchange, which persist throughout the postoperative period;[7]
- atelectasis formation in dependent lung regions develops after a few minutes of anaesthesia and may significantly impair pulmonary gas exchange;[8]
- surgical trauma further alters respiratory function when respiratory muscles are disrupted because of the site of incision.

Of these factors, the choice of anaesthetic drugs and postoperative pain therapy is the easiest to influence. Therefore, it seems important to investigate whether the choice of anaesthetic drugs and postoperative pain therapy can influence postoperative outcome in older patients with COPD. This review summarises the available literature addressing this important issue.

1. Preoperative Evaluation and Preparation

1.1 Evaluation

Preoperative evaluation is essential in older patients with COPD to determine the severity of lung disease and to identify modifiable risk factors. A decision can then be made whether surgery should go ahead, be delayed or abandoned. In addition, in patients undergoing lung resection, pulmonary function testing and arterial blood gas analysis are required to predict if the patient will be able to tolerate such surgery.[9]

A preoperative chest x-ray should be done for any surgical procedure in all patients older than 60 years of age with a history of COPD.[10] The x-ray provides important information about the degree of hyperinflation of the lungs and whether respiratory infection is present. For patients with lung disease under consideration for upper abdominal surgery or thoracic procedures, the preoperative evaluation should also include measurement of lung function by spirometry and gas exchange by arterial blood gas analysis.[9]

Recent studies have demonstrated that abnormal preoperative FEV_1, abnormal diffusing capacity, hyperinflation and mucous hypersecretion were predictive of severe postoperative pulmonary complications in patients undergoing upper abdominal surgery.[11-13]

Table I summarises 'cut-off values' for thoracic procedures. An FEV_1 above these values has an associated mortality rate of 7.5%. If values are below these cut-off points, split lung function studies should be performed.[9] Perfusion lung scintigraphy is very accurate in predicting residual post-resectional lung function in selected patients.[14] A predicted postoperative FEV_1 (with an associated mortality rate of 7.5%) of 0.8–1.0L is the generally accepted minimum value for post-resection survivability.[15]

Table I. Minimum values of forced expiratory volume in 1 second (FEV_1) for thoracic procedures with low mortality and incidence of pulmonary complications

Procedure	FEV_1 (L)[a] [% predicted]	References
Pneumonectomy	>2 [80%]	16,17
Lobectomy	1–1.5 [40–60%]	16,18,19

a Patients with FEV_1 above these values usually do not require further pulmonary function testing.

1.2 Preparation

Treatment of COPD includes inhaled β_2-adrenoreceptor agonists and anticholinergics, inhaled or systemic corticosteroids and oral or intravenous methylxanthines (e.g. theophylline, aminophylline). If patients with severe COPD are on long-term corticosteroids, the goal is to have them on the lowest effective dose preoperatively, with stress-dose corticosteroids in the perioperative period. Long-term medication, i.e. theophylline and inhaled bronchodilators or corticosteroids should be maintained until the time of surgery.[20] Ongoing respiratory infections should be treated aggressively during the preoperative period. When laboratory parameters such as C-reactive protein and leucocytes are elevated and productive cough is present, elective surgery has to be delayed. Preoperative cessation of smoking and physical therapy decrease the incidence of postoperative respiratory complications.[21]

Premedication in order to reduce anxiety is controversial in older patients, because of the danger of respiratory depression. However, anxiety may lead to increased respiratory frequency, which augments pulmonary hyperinflation and dyspnea and therefore a small dose of an anxiolytic might be beneficial.[22] The decision has to be made on a case by case basis. Oral midazolam (3.75mg) and clonidine (0.075mg) are suitable drugs in the elderly.[23] Cheaper alternatives are oral diazepam (5mg) or temazepam (10mg). Sedative drugs should be administered to a patient with severely limited pulmonary function in a well monitored environment.

Outpatient surgery is becoming increasingly popular in order to reduce healthcare costs. Older patients with severe COPD requiring general anaesthesia for surgery are rarely suitable for outpatient care.

Table II. Influence of anaesthetics and opioids on airway-reactivity

Agent	Mechanism	References
Anaesthetics		
Halothane; enflurane; isoflurane; sevoflurane	Induce bronchodilation, attenuate airway constriction, decrease respiratory resistance	24-26
Desflurane	Absence of bronchodilation	26
Propofol	Induces bronchodilation: blunts airway reflexes	27
Thiopental	Absence of bronchodilation	26
Etomidate	Absence of bronchodilation	28
Ketamine	Induces bronchodilation	29,30
Opioids		
Morphine	Histamine liberation (theoretical concern)	31,32
Fentanyl; alfentanil; sufentanil; remifentanil	Truncal muscle rigidity	33,34

2. Choice of Anaesthetic Agent

Table II summarises the influences of the different anaesthetics and opioids on airway-reactivity.

2.1 Volatile Anaesthetics

Volatile anaesthetics are potent bronchodilators. Halothane, enflurane and isoflurane attenuate airway constriction by several mechanisms, including reduced excitability of the post-synaptic nicotinic receptors of the intramural parasympathetic ganglia and a direct relaxing effect on airway smooth muscles and/or on muscarinic receptors.[24] The use of halothane is limited because of its myocardial depressant reaction and arrhythmic effects, as well as its hepatotoxicity. Halothane and isoflurane dilate airways in a dose-dependent manner; however, at low concentrations halothane is a more effective bronchodilator than isoflurane at equivalent minimal anaesthetic concentration (MAC) doses.[25] Sevoflurane is superior to desflurane for suppressing moderate and severe responses to airway stimulus [35] and for reducing respiratory resistance.[26] The pharmacological profile of sevoflurane may be beneficial in geriatric patients because of its low blood solubility allowing rapid changes to be made in anaesthetic depth and enabling early recovery. Comparable with all other volatile anaesthetics, the MAC dose for sevoflurane is reduced in elderly patients.[36] However, that there is no study that says that sevoflurane should be primarily chosen over isoflurane.

2.2 Intravenous Anaesthetics

The intravenous anaesthetic drugs thiopental and etomidate can be safely used for induction in elderly patients with COPD, even though no direct bronchodilating effect has been demonstrated and they are ineffective in blunting airway reflexes.[28] Propofol seems to blunt airway reflexes better than thiopental or etomidate; this is probably the most important mechanism by which it reduces bronchospasm during intubation.[28] In addition, propofol induces bronchodilatation in patients with COPD, therefore respiratory mechanics improve after propofol infusion as shown by increased dynamic compliance, decreased peak inspiratory pressure and decreased minimal resistance of the respiratory system.[27] However, propofol has to be administered very cautiously in elderly subjects, otherwise severe haemodynamic adverse effects such as hypotension and cardiac depression are likely to occur.[37] The pharmacokinetics and pharmacodynamics of propofol are quite different in older patients.[38] The propofol induction dose has to be reduced by 60% and the infusion rate should be reduced by 30–50% in patients >65 years of age.[38]

Ketamine is a suitable drug in patients with COPD for induction and maintenance of anaesthesia, since it is a bronchial smooth muscle relaxant and is as effective as halothane or enflurane in preventing experimentally induced bronchospasm.[29,30] Fentanyl, alfentanil, sufentanil and remifentanil cause almost no histamine release, although they may produce truncal muscle rigidity, which can

be reversed by muscle relaxants.[33,34] They are twice as potent in elderly compared with younger subjects. Morphine may increase plasma histamine concentrations and thereby increase bronchial tone,[32] which is more a theoretical concern, since many patients tolerate morphine without problems. The new short-acting opioid remifentanil allows hypnotic dose reduction and facilitates early recovery.[39] Doses must be reduced in the elderly.[40] In order to reduce adverse cardiovascular effects, a target-controlled infusion of remifentanil is superior to a continuous weight-adjusted infusion.[41]

2.3 Neuromuscular Blocking Agents

Neuromuscular blocking agents may produce unwanted autonomic nervous system effects and affect airway diameter and reactivity by promoting histamine release.[42] Suxamethonium (chloride) may be used in patients with COPD for rapid tracheal intubation, if absolute contraindications such as hyperkalaemia, renal failure, increased intracranial pressure, increased intraocular pressure and myopathies are not present.[43] However, suxamethonium-induced cardiac arrhythmias occur frequently and therefore well-judged use is crucial in elderly patients.

Neuromuscular blocking agents in the benzylisochinolinium group (tubocurarine, metocurine, doxacurium [chloride], atracurium [besilate], cisatracurium [besilate] and mivacurium [chloride]) generally exhibit a tendency to cause histamine release, although this adverse effect is slight in atracurium and mivacurium and absent in cisatracurium.[42] Muscle relaxants with prominent histamine release should be avoided at all cost in patients with COPD. Neuromuscular blocking agents in the corticosteroidal group (pancuronium [bromide], pipecuronium [bromide], vecuronium [bromide], and rocuronium [bromide]) generally do not cause histamine liberation. Rocuronium has the most rapid onset of action among the available nondepolarising drugs and is therefore an alternative choice for rapid sequence induction. A dosage of 0.6 mg/kg allows intubation within 75 seconds.[44]

As deep muscle relaxation is not necessary for most surgical procedures,[45] muscle relaxants should be used judiciously. Most of the neuromuscular blocking agents have an increased onset time and duration of action in the elderly.[46-48] Moreover, duration of action is variable regardless of the drug chosen. Therefore, monitoring of neuromuscular blockade using a nerve stimulator might be very helpful.

Residual paralysis is frequently observed in the postoperative period, and may increase postoperative morbidity, e.g. from hypoxaemia, pulmonary infection and delayed recovery.[49] If residual paralysis is manifest at the end of the procedure, either neostigmine (0.05 mg/kg), mixed with glycopyrronium (bromide) [0.4–0.5mg] or atropine (7–10 μg/kg), should be administered carefully. The elderly are more susceptible to the adverse effects of neostigmine, especially to cardiac arrhythmias; however, the problems of residual paralysis outweigh the adverse effects of neostigmine. Atropine may cause postoperative confusion in elderly patients, therefore glycopyrronium should be chosen if available.

3. Mechanical Ventilation

Mechanical ventilation of patients experiencing COPD must ensure sufficient arterial oxygenation and strictly avoid gas trapping, which can lead to a pneumothorax and a decrease in cardiac output. The main stimulus for regulation of breathing in patients with partial respiratory insufficiency (resting hypercapnia) is the arterial carbon dioxide partial pressure ($PaCO_2$). A substantial decrease in $PaCO_2$ during mechanical ventilation leads to suppression of spontaneous breathing, thus, leading to prolonged time of intubation.[50] Whereas, in patients presenting preoperatively with global insufficiency (arterial oxygen partial pressure [PaO_2] <50mm Hg and $PaCO_2$ >50mm Hg) the major stimulus for ventilation is low PaO_2. Therefore, the administration of oxygen with concomitant high PaO_2 values can potentially lead to life threatening hypoventilation in these patients.

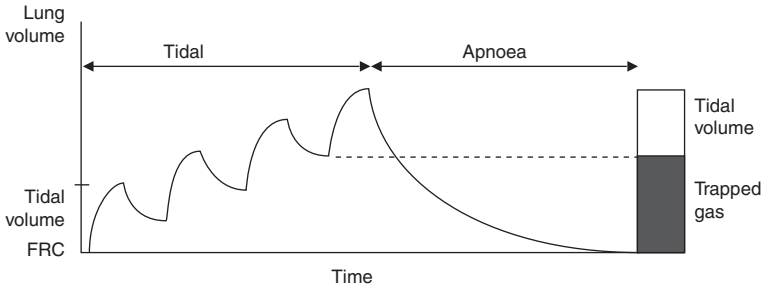

Fig. 1. Development of dynamic hyperinflation during mechanical ventilation and representation of lung deflation during apnoea. **FRC** = functional residual capacity (reproduced from Myles,[52] with permission).

Pulmonary hyperinflation associated with intrinsic positive end-expiratory pressure ($PEEP_i$) is a major problem in patients with advanced COPD. Causes of pulmonary hyperinflation are the loss of lung elastic recoil and abnormal airflow resistance.[51] In a patient with airway obstruction, the expiratory flow is too slow to fully evacuate the lungs before the next breath is initialised, resulting in air-trapping and dynamic hyperinflation. This creates a positive alveolar pressure which, during spontaneous breathing, must be overcome before subsequent inspiratory flow begins, leading to an increased work of breathing. This end expiratory positive alveolar pressure caused by dynamic hyperinflation is named PEEPi or auto-PEEP. During mechanical ventilation close attention to the occurrence of dynamic pulmonary hyperinflation, with the risk of barotrauma and the burden of excessive extrinsic PEEP causing circulatory depression, are the most important issues.

The magnitude of dynamic hyperinflation and $PEEP_i$ can be substantially influenced by the ventilator setting, namely, tidal volume, respiratory frequency and inspiratory to expiratory time ratio. Thus, ventilation should be performed by using moderate tidal volumes (<9 mL/kg during normal ventilation and <5 mL/kg during one-lung ventilation [OLV]), low respiratory frequencies (10–12 breaths per minute during ventilation of both lungs and <16 breaths per minute during OLV), and a long expiratory time (e.g. ratios of 1 **:** 3 and longer are recommended). Dynamic pulmonary hyperinflation and $PEEP_i$ must be suspected if the shape of the end-expiratory flow indicates the lack of an end-expiratory pause in the flow-time record (figure 1). Furthermore, the shape of the end-tidal CO_2 curve is diagnostic of hyperinflation.

Most respirators are able to show if exhalation is complete, which means expiratory flow must reach zero before the onset of the next inspiratory phase. Simply, $PEEP_i$ can be estimated by occluding the exhalation valve of the ventilator at end-expiration, while monitoring the flow curve and recording the pressure. Accurate measurements of hyperinflation and $PEEP_i$ are usually not feasible in the operating theatre and the reader is referred to more specialised articles.[53]

One of the goals in ventilating patients with COPD is to keep the plateau pressure less than 30cm H_2O. Minimising minute ventilation in order to restrict airway pressure and avoid barotrauma may result in hypercapnia and respiratory acidosis (permissive hypercapnia). A decrease in pH to 7.15 and a rise in $PaCO_2$ to 80mm Hg are well-accepted limits with permissive hypercapnia.[54] The use of permissive hypercapnia is contraindicated in patients with elevated cranial pressure, severe hypotension, severe metabolic acidosis, hypovolaemia, severe refractory hypoxaemia, severe pulmonary hypertension, concomitant use of β-adrenoreceptor antagonists and presence of coronary artery disease.

The use of external PEEP less than or equal to 85% of $PEEP_i$ improves respiratory mechanics and decreases work of breathing.[55]

4. Regional Versus General Anaesthesia

A haemodynamically stable anaesthetic regimen is especially important in elderly patients because cardiovascular aging promotes haemodynamic instability. The response to β-receptor (β_1 and β_2) stimulation diminishes with aging[56,57] and the baroreflex system is not as effective at increasing heart rate in order to increase cardiac output.[58]

Whether the type of anaesthesia (general versus regional) has any substantial effect on perioperative morbidity and mortality remains a matter of debate. A better outcome for either regional or general anaesthesia has not been shown in a large, prospective trial neither in all patients nor in elderly patients with COPD. Most patients with severe COPD (FEV_1 less than 50% predicted and FEV_1/FVC less than 70% predicted) undergo abdominal surgery with a considerable, yet acceptable risk for pulmonary complications under general anaesthesia.[59] However, there are some aspects that might influence the decision towards regional anaesthesia in elderly patients with COPD.

Most obviously, regional techniques are associated with the advantage of not manipulating the respiratory system in patients with hyper-reactive airways. In addition, the 'stress response' created by major surgery is substantially altered by neuraxial blockade but not by general anaesthesia.[60] The advantage of regional anaesthesia was extensively studied in elderly patients undergoing orthopaedic procedures. A decrease in intraoperative blood loss and decreased incidence of deep vein thrombosis have been documented.[61,62] Pedersen concluded that regional anaesthesia may be a superior technique compared with general anaesthesia, especially in elderly patients with COPD admitted to major orthopaedic surgery.[63] However, even the largest individual trial to date in patients with hip surgery did not have the power to detect significant differences in mortality between the two techniques.[64]

The trials discussed in this paragraph were not exclusively in elderly patients with COPD; however, their findings should be taken into consideration when an anaesthetic plan is performed for the elderly patient. Unfortunately, no outcome trials exist to date where exclusively elderly patients with COPD have been studied. In a landmark study, Yeager et al. demonstrated a reduction in overall postoperative complications and less stress response in high-risk surgical patients who received epidural-general anaesthesia and postoperative epidural analgesia compared with patients receiving general anaesthesia alone.[65] Carli and Halliday compared combined epidural-general anaesthesia and postoperative epidural analgesia with general anaesthesia and parenteral analgesia.[66] The later proved to be inferior in respect of suppression of the 'stress response' related to surgery. Results from a meta-analysis of randomised trials have shown a reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia compared with general anaesthesia (figure 2).[67] Overall mortality was reduced by about a third, deep vein thrombosis by 44%, pulmonary embolism by 55%, transfusion requirements by 50%, pneumonia by 39% and respiratory depression by 59% in patients allocated to neuraxial blockade. However, the recently published Australian master trial revealed no significant difference in mortality for either type of anaesthesia in high-risk patients.[68]

In severely compromised COPD patients, neuraxial block has to be used with caution because of potential paralysis of the respiratory muscles. Reducing expiratory reserve volume in a marginal patient who is dependent on active exhalation might lead to respiratory depression. In addition, expiratory muscles are important for effective coughing and clearing of secretions. Interscalene blocks cause a transient phrenic nerve paresis and these blocks are contraindicated in patients with severe COPD. Also, segmental high thoracal epidural anaesthesia may cause pulmonary sympathetic and respiratory motor blockade. Whether it can be safely used for chest wall surgery as a primary anaesthetic technique in patients with COPD or asthma was recently studied by Groeben et al.[69] Despite sympathetic blockade, thoracic epidural analgesia did not increase airway obstruction and induced only a small decrease in FEV_1 as a sign of mild respiratory motor blockade with no difference between ropivacaine and bupivacaine. Eight patients out of 20 were older

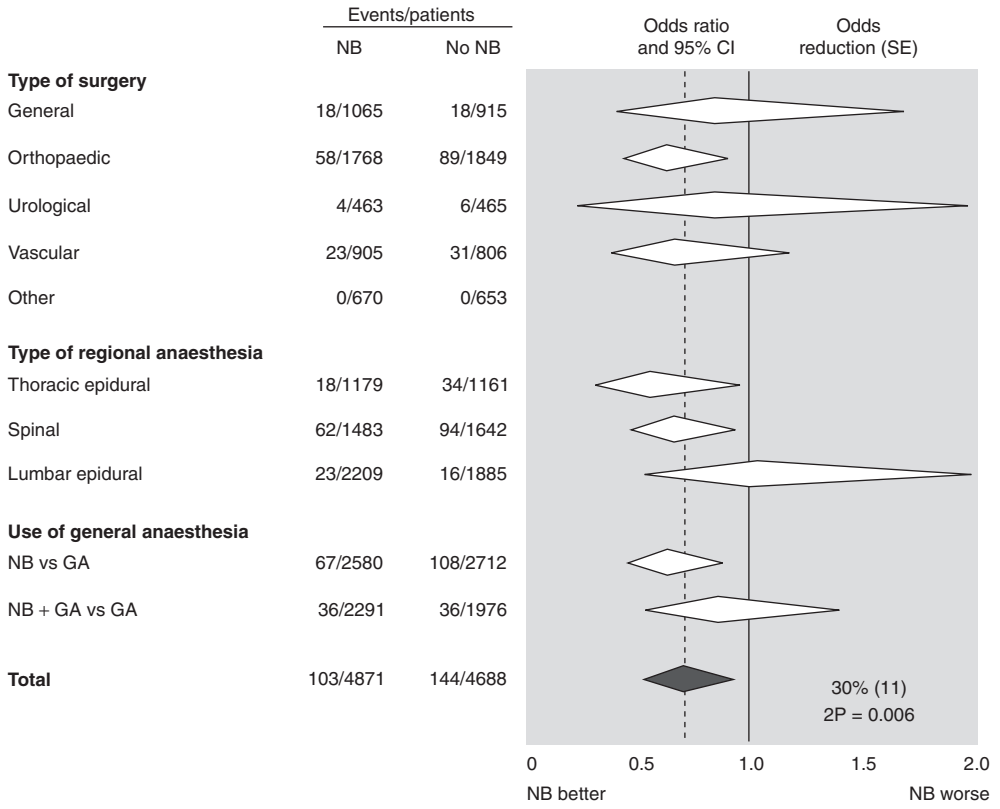

Fig. 2. Effect of neuraxial blockade (NB) on postoperative mortality by surgical group, type of NB and use of general anaesthesia (GA). Diamonds denote 95% CIs for odd ratios of combined trial results. The vertical dashed line represents the overall pooled result. Chi square test for heterogeneity between different surgical groups p = 0.9 (reproduced from Rodgers et al.,[67] with permission).

than 65 years in this study. Unfortunately, no trials exist where only elderly patiens with COPD have been studied.

The intraoperative effects of continuous spinal anaesthesia and the efficacy of postoperative continuous spinal analgesia (CSA) in elderly high-risk patients undergoing major abdominal, vascular or orthopaedic surgery were recently re-evaluated in two studies. [70,71] CSA was performed with a microcatheter (28G). Only minimal cardiovascular and respiratory adverse effects were observed compared with single shot spinal and general anaesthesia. The main benefit of CSA is the option of applying a second dose to maintain the optimal anaesthetic level and to provide postoperative analgesia for 2–3 days. However, after reports of cases of cauda equina syndrome occurring after continuous spinal anaesthesia, the technique is less frequently used.[72]

5. Special Considerations for Thoracic and Cardiac Anaesthesia

In the following section, special considerations for major thoracic and cardiac anaesthesia are elucidated. In thoracic and cardiac procedures the diseased organ (lungs) is directly affected by the type of surgery.

5.1 Thoracic Anaesthesia

A five-lead ECG, a pulse-oximeter, an arterial line, a temperature probe and very often a central venous catheter are necessary for appropriate monitoring of older patients with COPD undergoing tho-

racic surgery. The use of pulmonary artery catheters in high-risk patients is controversial, although pulmonary artery pressure may increase substantially during single lung ventilation and surgical clamping of the pulmonary vessels.

5.1.1 Ventilation Considerations

Variable periods of OLV are required during thoracic procedures to facilitate surgery. OLV with subsequent decreases in oxygenation may especially endanger patients with severe COPD. Intrapulmonary shunting of deoxygenated pulmonary arterial blood may further decrease oxygenation and contribute to severe hypoxaemia.

The major protective pathophysiological mechanism against hypoxaemia is hypoxic pulmonary vasoconstriction (HPV) which distributes blood from non-ventilated to ventilated areas of the lung. However, in patients with severe COPD, HPV may not be an effective protective mechanism because these patients already have increased pulmonary arterial pressure and a reduced pulmonary vascular bed. The administration of inhaled nitric oxide during OLV in order to improve oxygenation by selectively decreasing pulmonary resistance and increasing blood flow to the ventilated lung is ineffective.[73] The effects of external 5cm H_2O PEEP on oxygenation during OLV correspond to individual changes in the relationship between the plateau end-expiratory pressure and the inflection point of the static compliance curve. Oxygenation might improve or deteriorate, depending whether the application of PEEP causes the end-expiratory pressure to increase from a low level toward the inflection point or causes an increased inflation of the ventilated lung that raises the equilibrium end-expiratory pressure beyond the inflection point.[74]

5.1.2 Anaesthetic Considerations

Thoracic epidural anaesthesia combined with general anaesthesia for thoracic surgery is increasing in popularity. It is also the method of choice at our institution, especially when patients have COPD and impaired pulmonary function. General anaesthesia alone, either total intravenous or with volatile anaesthetics are alternative methods. Regional anaesthesia alone is never performed during major thoracic procedures. The choice is either general anaesthesia alone or a combined regimen (regional and general anaesthesia). Advantages of a combined regimen (general anaesthesia plus epidural anaesthesia) include less shunting and better oxygenation during OLV, especially in COPD patients[75] and less respiratory complications[76] and reduced pain scores postoperatively.[77]

Usually, a thoracic epidural catheter is placed, immediately prior to induction of anaesthesia, at the level T4-T5 or T5-T6. After testing the position with 2–4ml of lidocaine 2% and appropriate volume loading (10–20 ml/kg), induction of anaesthesia is performed. Following induction, during the period of chest incision, a bolus of bupivacaine 0.5% or ropivacaine 0.75% is administered in 2ml increments up to 8ml. A potent vasopressor should be available to prevent severe hypotension.

A potential threat of thoracic epidural analgesia might be the paralysis of respiratory muscles and changes in bronchial tone in patients with end-stage chronic COPD. This was studied at our institution and we found that thoracic analgesia with bupivacaine 0.25% did not impair ventilatory mechanics and inspiratory muscle strength.[78] Potential disadvantages of thoracic epidural anaesthesia are complications such as epidural abscess, epidural haematoma, (although the risk is very low) and the time required establishing epidural anaesthesia.

Many anaesthesiologists performing thoracic anaesthesia for high-risk patients are convinced that thoracic epidural analgesia not only provides excellent pain relief, but also reduces postoperative morbidity and mortality. However, it has to be mentioned that no individual trials are available, to date, to confirm this.

During the immediate postoperative period an intercostal nerve blockade can provide excellent pain relief after thoracotomy. The intercostal nerve blockade is a technically simple, safe and quick procedure, although the short duration of action limits its use.[79] We perform an intercostal nerve blockade in all patients who do not receive thoracic epidural analgesia. At the end of surgery, nerves from the thoracic segments T2-T7 are anaesthetised

using either bupivacaine 0.25% or 0.50% alone or bupivacaine plus clonidine 2 μg/kg. Adding clonidine to bupivacaine enhances analgesia and improves oxygenation for a short time postoperatively.[80]

5.2 Cardiac Anaesthesia

Cardiac surgery in the elderly is a high-risk procedure. Age >65 years and COPD are among the perioperative predictors of extubation failure after cardiac surgery.[81] Furthermore, the presence of COPD is associated with increased length of stay in the intensive care unit and in the hospital.[82] Preoperatively decreased FEV_1 significantly delays extubation and prolongs the length of hospital stay. In addition, decreased preoperative FEV_1 is even a significant predictor of 5-year survival.[82] The surgical method might influence postoperative outcome in patients with COPD. Off-pump bypass surgical procedures seem to be more advantageous than on-pump methods in terms of extubation time, duration of intensive care unit stay and postoperative lung function.[83]

Regional anaesthetic techniques are being used with increasing frequency by anaesthesiologists treating patients undergoing cardiac surgery. This tendency is because of the potential perioperative benefits including excellent postoperative analgesia, 'stress response' attenuation and thoracic cardiac sympathectomy. However, the potential risk of epidural haematoma and spinal lesions makes it necessary to evaluate potential benefits carefully. Scott et al. performed an open, prospective, randomised, controlled study of the incidence of major organ complications in 420 patients undergoing routine coronary artery bypass graft surgery with or without thoracic epidural analgesia. Patients included in the trial were not exclusively elderly individuals with COPD.[84] All patients received standardised general anaesthetic. There were less new supraventricular arrhythmias, better pulmonary function, earlier extubation, lower numbers of respiratory tract infections and fewer patients with acute confusion, stroke and acute renal failure in the thoracic epidural analgesia group. No neurological complications were observed with the use of thoracic epidural analgesia and quality of recovery was significantly improved compared with conventional opioid analgesia.

6. Postoperative Analgesia

Optimal pain therapy is an essential requirement in the postoperative period to maintain or to restore pulmonary function. Several routes of administration exist for pain relief. Frequently, adequate pain control needs a combination of agents and techniques. A balanced analgesic regimen consisting of regional analgesia with local anaesthetics and NSAIDs should be used. However, careful intravenous opioid titration or patient controlled analgesia (PCA) with opioids, in combination with NSAIDs, might be equally appropriate.

6.1 Agents

Opioids are highly effective for postoperative analgesia, although they carry a higher risk of respiratory depression, which is especially dangerous in patients with COPD. Doses must be reduced by 50% of the standard adult dose in elderly patients with COPD in order to limit adverse events while maintaining an equivalent level of analgesia. PCA with opioids can be used systemically (intravenous administration) or with regional techniques (e.g. epidural administration) in elderly patients. Morphine is the most widely used and presently the most suitable drug for PCA in the elderly.[85] Close monitoring and evaluation of the patient throughout the perioperative period is required to ensure the appropriate and successful use of PCA. Pulse-oximetry is very helpful for this purpose. Studies have indicated that, after acute pain control, PCA with morphine should be initiated at a dosage of 1 or 1.5mg per dose, with a lockout period of 5–7 minutes. Continuous background infusions of opioids are contraindicated.[85] PCA is well-accepted by older patients, they attain comparable levels of analgesia and are equally satisfied with their pain control as younger patients.[86] However, when patients are unable to manage a PCA, the nurse or physician can titrate intravenous morphine. Intravenous morphine is ti-

trated as a bolus of 2mg (bodyweight ≤60kg) or 3mg (bodyweight >60kg) in 5-minute intervals until complete pain relief is achieved.[87]

Tramadol is a synthetic, weak opioid agonist and an inhibitor of monoamine neurotransmitter reuptake. Unlike other opioids, tramadol has no clinically relevant effects on respiratory or cardiovascular parameters at recommended doses.[88] Tramadol may prove particularly useful in patients with poor cardiopulmonary function, including the elderly, the obese and COPD patients. In patients with impaired hepatic or renal function, tramadol should be used instead of NSAIDs.[88] The most common adverse events (incidence of 1.6–6.1%) are nausea, dizziness, drowsiness, sweating, vomiting and dry mouth.[88] Recently, continuous intravenous tramadol has been shown to be an alternative to neuraxial or systemic opioids for the management of post-thoracotomy pain.[89]

NSAIDs such as ibuprofen, naproxen, or diclofenac are effective postoperative analgesics. Unless they are contraindicated or there is a strong concern about haemostasis or peptic ulceration, a scheduled parenteral, rectal or oral NSAID, should be added to the patients pain regimen in order to reduce opioid consumption, enhance analgesia and decrease inflammatory mediators. Clinical benefits include less drowsiness and lack of respiratory adverse effects. This is important in patients with COPD where respiratory depression is especially dangerous.

NSAIDs should be administered with caution in elderly patients who are at risk of developing renal dysfunction.[90] The standard adult dosage of NSAIDs should be decreased by 40–60% in elderly patients. If renal dysfunction is already present, NSAIDs should not be used at all. Selective cyclooxygenase-2 inhibitors may represent a safer alternative to nonselective NSAIDs in the treatment of postoperative pain, since they are associated with less gastric injury[91] and do not influence haemostasis.[92] Careful monitoring of blood pressure is warranted in elderly patients with hypertension when treatment with celecoxib or rofecoxib is started. A recent trial has suggested that rofecoxib increases blood pressure to a greater extent than celecoxib.[93]

6.2 Regional Techniques

Patient-controlled epidural analgesia (PCEA), using an opioid either alone or in combination with a local anaesthetic, has been proven to be beneficial in the management of pain relief after major surgery.[94] Seventy patients >70 years of age undergoing major abdominal surgery received either combined epidural analgesia and general anaesthesia followed by postoperative PCEA, using a mixture of 0.125% bupivacaine and 0.5μg/ml sufentanil, or general anaesthesia followed by PCA with intravenous morphine. Postoperatively, the group received the bupivacaine and sufentanil mixture via a PCEA pump programmed to deliver a 2 or 3ml bolus with a lockout interval of 12 minutes and a background infusion of 3–5 ml/h. The PCA group received an initial loading dose of intravenous morphine up to 5mg. Then the PCA pump was programmed to deliver a bolus of intravenous morphine 1.5mg with a lockout interval of 8 minutes. The epidural route using local anaesthetics and an opioid provided better pain relief and improved mental status and bowel activity.[94]

Since no individual trial to date has conclusively shown that postoperative epidural pain control improves pulmonary outcome, Ballantyne et al. performed a cumulative meta-analysis to compare seven postoperative analgesic therapies and their influence on pulmonary outcome.[76] Compared with systemic opioids, epidural opioids and local anaesthetics decreased the incidence of pulmonary morbidity. Intercostal nerve blockade tends to improve pulmonary outcome measures but the differences compared with systemic opioids were not significant. A benefit of postoperative thoracic sympathetic blockade by thoracic epidural bupivacaine after pulmonary resection is to reduce supraventricular tachyarrhythmias that may result from the relative sympathotonic status produced by injury to the cardiac parasympathetic nerves.[95]

7. Conclusion

Anaesthesia in older patients with COPD requires careful evaluation and preparation of the patients. The pathophysiological changes associated with aging and COPD need well-planned anaesthetic management, which should continue into the postoperative period. Many anaesthetic agents, neuromuscular blocking agents and analgesics are suitable. However, with increasing age and comorbidities, the number of drugs that can be used safely become limited.

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