Regional anaesthesia may affect respiratory muscle function, pulmonary bronchial tone and postoperative pulmonary dysfunction. These effects on respiratory function depend on the concentration of the local anaesthetic used and, mostly, on the location of the regional block. Most peripheral nerve blocks have no effect on respiratory function and are, therefore, often recommended as the technique of choice for respiratorily-compromised patients. The only exception is the interscalene block which will affect respiratory muscle function. The major concern is linked to thoracic epidural anaesthesia which may affect respiratory muscle function and bronchial tone.

**Interscalene block**

An interscalene block will also block the phrenic nerve. This is not a complication but a normal effect of due to the diffusion of the local anaesthetic to the C3-C4 roots. This phrenic blockade is usually well tolerated but may be problematic for a respiratory compromised patient (elderly, COPD or morbidly obese patients). After interscalene block, vital capacity is decreased by a mean of 25% within 1 s; FEV₁ and PaO₂ are also decreased. This effect will last 3-5 h [1].

In order to prevent this effect of interscalene block, it has been proposed that the amount of local anaesthetic injected should be reduced (traditionally 40 ml). However, there is still a high incidence of phrenic blockade and a decrease in the quality of the interscalene block. Finger compression above the level of injection is ineffective in preventing phrenic block.

General recommendations are to avoid this block in patients with contralateral respiratory pathology (for example, phrenic paresis, pneumonectomy, pneumothorax) and in respiratorily compromised patients who will not tolerate a decrease in their vital capacity by 25%. This block is not recommended in patients with a vital capacity < 1.5 l [2].

**Epidural anaesthesia**

Epidural administration of local anaesthetics can provide excellent anaesthesia and analgesia for surgical procedures from the neck to the toes. In addition to this primary function, the inevitable sympathetic blockade can have a significant beneficial effect on several organ systems. It can increase gastrointestinal motility and perfusion, decrease myocardial ischaemia and reduce the systemic stress response [3]. However, the impact of epidural anaesthesia on lung function can be difficult to determine. Effective analgesia, the avoidance of mechanical irritation by airway instrumentation, and removing the need for mechanical ventilation must be balanced against the possible alteration in lung function by epidural motor blockade of respiratory muscles and the potentially detrimental effects of sympatholysis, leaving an unopposed vagal tone and potentially increased bronchial tone and reactivity. The physiological effects of epidural anaesthesia on lung function without any surgical intervention are determined by the extent of the motor blockade, the extent of which and its relevance for lung function depend on the spinal level of insertion of the catheter and on the concentration of the local anaesthetic used.

**Lumbar epidural anaesthesia**

Even with an extensive block beginning in the lumbar region, the decrease in vital capacity has been described as only 3%. Usually, a change in vital capacity is noticed by the patient only if it decreases by 10% or more. Therefore, this minor change should not be clinically relevant [4].
Thoracic epidural anaesthesia

With the administration of local anaesthetics into the thoracic epidural space some significant alteration to lung function can be expected. With a limited sensory blockade from T1 to T5, vital capacity is decreased by 5.6% and FEV₁ by 4.9% [5]. This effect can be explained by a direct motor blockade of the intercostal muscles. This increases with the extent of the sensory blockade. An epidural blockade extending from dermatome C4 to T7 or from T5 to L4 led to a decrease of 25% in vital capacity, and a decrease in FEV₁ of 13% [6]. On the other hand, studies in COPD patients have shown that an epidural block with bupivacaine 0.5% to produce a sensory blockade of C4 to T8 leads to a decrease in vital capacity and FEV₁ of only 8% from baseline [7].

Looking at overall lung function (gas exchange), concerns about a ventilation/perfusion mismatch from high thoracic epidural anaesthesia could not be proven. Neither the arterial–alveolar difference in PaO₂ (AaDO₂) nor the direct measurement of shunt showed any significant difference [8]. Overall, thoracic epidural anaesthesia with a sensory blockade up to the mid-cervical region did change vital capacity and FEV₁ significantly, but only by an amount which was safe for clinical use.

Cervical epidural anaesthesia

Cervical epidural anaesthesia reduces vital capacity and FEV₁ by about the same amount as high thoracic epidural anaesthesia reaching up into the low cervical dermatomes. Movement of the diaphragm, as well as the forced sniff test, showed a significant reduction, indicating at least a minor attenuation of diaphragmatic force. The use of cervical epidural anaesthesia was evaluated in a series of 324 patients undergoing carotid artery surgery. Following the administration of bupivacaine (0.375% or 0.5%), the mean sensory blockade was from C2 to T4 [9]. Three out of the 324 patients (0.8%) had to be intubated because of respiratory insufficiency, while in another study evaluating cervical epidural anaesthesia for similar surgery, none of the 215 patients had to be intubated [10].

Overall, the use of cervical epidural anaesthesia seems to be a practical, and, so far, a safe alternative to general anaesthesia. Only with the use of high concentrations of local anaesthetics (bupivacaine 0.5%) is there a small risk of developing a high motor blockade with the need for respiratory support.

Epidural anaesthesia in respiratorily compromised patients

General anaesthesia with instrumentation of the airways can elicit bronchospasm and life-threatening complications. Undoubtedly, the use of regional anaesthesia helps to avoid airway irritation. Therefore, it is not surprising that surgical procedures performed under spinal or epidural anaesthesia are associated with fewer respiratory complications as compared with the same procedures under general anaesthesia in respiratorily compromised patients. However, the use of high thoracic epidural anaesthesia raises two major concerns. Firstly, the motor blockade that is associated with epidural anaesthesia could lead to respiratory decompensation in patients with an already compromised respiratory function. Secondly, the sympathetic blockade, which is also associated with epidural anaesthesia, could lead to increased bronchial tone and airway hyperreactivity.

Effect of motor blockade

High thoracic epidural anaesthesia with a sensory blockade from C4 to T8 did not change FRC and reduced both FEV₁ and vital capacity by 8-10%, which was not detected by patients as respiratory distress [11]. Overall, this effect was smaller than the effect of a change in position from sitting to supine, which causes > 10% decrease these parameters, and which is the effect that can be seen following general anaesthesia with muscle relaxation.

Overall, high thoracic epidural anaesthesia seems not to affect lung function more in patients with COPD and bronchial hyperreactivity than in patients free from respiratory diseases.
Effects in patients with bronchial hyperreactivity

An investigation into the effects of high thoracic epidural anaesthesia on bronchial reactivity has been performed in patients with COPD who received a high thoracic epidural for upper abdominal surgery [11]. Following the epidural administration of 7–8 ml bupivacaine 0.75%, a sensory block from C4 to T8 developed. To detect an increase in bronchial tone, FEV$_1$ in relation to vital capacity and airway resistance were measured. The results showed no evidence of increased bronchial tone. However, the threat remained that with a strong stimulus such as the tracheal intubation reflex, bronchoconstriction may lead to severe bronchospasm. To test this an inhaled bronchial challenge with acetylcholine was administered before and after establishment of the high thoracic epidural anaesthesia. At first sight the results were surprising, because the patients did not show an increased reactivity, but showed an attenuation of their reactivity. The acetylcholine threshold for a 20% decrease in FEV$_1$ was raised three times the baseline level, in other words the patients became significantly less responsive. The explanation is that intravenous administration of bupivacaine also attenuates bronchial reactivity (up to three-fold reduction). In another study patients with severe COPD and a history of markedly increased bronchial reactivity under went mastectomy and axillary lymph node dissection with reconstruction under high thoracic epidural anaesthesia with mild sedation and no general anaesthesia [7]. FEV$_1$ and vital capacity were measured in the sitting position, the prone position, and then with high thoracic epidural anaesthesia. The change from the sitting to the prone position led to a bigger change in FEV$_1$ and vital capacity than the establishment of epidural anaesthesia. In addition the ratio of FEV$_1$/VC, to vital capacity improved, suggesting that the administration of local anaesthetics decreases the bronchial tone rather than increasing it. In no cases did epidural anaesthesia have to be converted to general anaesthesia, and none of the patients developed postoperative pulmonary complications.

Several studies and meta-analyses have shown a reduction in postoperative complications when general anaesthesia was combined with epidural anaesthesia and postoperative epidural analgesia [12-14]. This effect can be explained as a result of early extubation, better analgesia during mobilization and coughing, attenuation of bronchial reactivity, and improved diaphragmatic function. Overall, the use of regional anaesthesia as the main anaesthetic technique, or in combination with general anaesthesia, can be recommended in patients with obstructive pulmonary disease.

Postoperative complications

Thoracic and major abdominal surgery often induce postoperative pulmonary dysfunction with reduced FRC, FEV$_1$, and vital capacity. These changes can last up to 14 days [15]. Thoracic epidural anaesthesia has been shown to blunt the reduction of FRC and vital capacity after abdominal surgery. It also prevents postoperative deterioration of respiratory function in patients undergoing cholecystectomy [16]. In order to avoid the risk of pulmonary infection and other adverse effects linked to prolonged mechanical ventilation, early extubation is desirable, even after major surgical procedures such as oesophageal resection [17-18]. Pain impairs the ability of patients to breathe deeply and to cough, thus leading to an increased risk of atelectasis. A recent meta-analysis found significant benefits of epidural analgesia as compared with intravenous PCA morphine. Epidural analgesia resulted in pain-free ventilation and increased abdominal ventilation in the postoperative period after thoracotomy and major abdominal surgery [19]. Ability to cough was also increased.

Key learning points

- Regional anaesthesia is particularly well suited in respiratorily compromised patients
- Interscalene block may be contra-indicated in respiratory compromised patients due to the associated phrenic block
- Thoracic epidural block has no deleterious effect on lung function and should be used for thoracic and high abdominal surgery in respiratory compromised patients
References