Thoracic Anesthesia in Geriatric Patients

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Introduction

Lung cancer is a major cause of cancer-related death in octogenarians (1). Surgery for lung cancer may result in serious life-threatening complications, and surgery itself may become the cause of death (2). In-hospital mortality ranges within 0.6-5.2% and is increased in elderly patients and in those suffering from compromised respiratory functions. Anesthetic management has thus to consider acute and chronic pulmonary diseases as well as age-related physiological changes and co-morbidity in geriatric patients. Additionally, the interference of the central anaesthesia target, i.e. the lung, with surgical manipulation requires particular techniques including partial or complete airway separation and is commonly associated with profound pathophysiological changes that may affect the postoperative outcome (3).

Several anaesthesia-related risk factors for respiratory failure have been identified including intraoperative high-tidal volume ventilation and excessive fluid load (4; 5) besides surgery related conditions such as duration of the procedure and extent of lung resection (6).

In contrast to the temporarily collapsed and subsequently surgically treated lung, the dependent lung is ventilated throughout the procedure. Despite the consequences of an extensively decreased lung volume, tidal volumes (V_T) in the range of 8-10mL/kg and zero end-expiratory pressure are commonly recommended for one-lung ventilation (OLV) to maintain arterial oxygenation and carbon dioxide elimination (7). As a result, OLV may be injurious in terms of increased mechanical stress characterized by alveolar cell stretch and overdistension, increased cyclic tidal recruitment and compression of alveolar vessels (8). It may result in ventilator-induced lung injury with development of permeability-type pulmonary edema, leukocyte recruitment, cytokine release and neutrophil-dependent tissue destruction.

Thus, the management of geriatric patients undergoing thoracic surgery may offer opportunities for anesthetic intervention including protective ventilation approaches, use of volatile anesthetics, restrictive fluid management and sufficient pain therapy.

Preoperative Evaluation

Respiratory complications significantly contribute to outcome after thoracic surgery. Consequently, preoperative lung function has to be evaluated carefully by clinical examination and lung function tests. The single most important parameter is the forced expiratory volume (FEV_1). Patients with FEV_1<70% (predicted) have an increased incidence of postoperative pulmonary complications. The most important variable is the global cardio-pulmonary reserve. A maximal oxygen

consumption <10ml/kg·min, and the inability of the patient to climb two flights of stairs indicate an increased perioperative risk (9).

Anesthetic management in patients undergoing thoracic surgery

The anesthetic setup includes induction of anesthesia with a hypnotic drug, a potent opioid and a muscle relaxant and is maintained either with an inhalational anesthetic (desflurane or sevoflurane) or propofol and an opioid. Most patients benefit from early tracheal extubation after surgery, thus, remifentanil combined with thoracic epidural anesthesia (TEA) may be an advantageous anaesthesiological strategy. Intravenous fluid should be given with care to avoid pulmonary edema. The elderly have a decreased ability to tolerate hemodynamic instability; thus, patients with compromised cardiac function should be more readily treated with positive inotropic drugs.

Alveolar recruitment maneuver (ARM) and PEEP

Atelectasis formation and intrapulmonary shunt increase are common problems during OLV. The ARM followed by sufficient PEEP application to keep the recruited lung regions open improves the pulmonary gas exchange especially during OLV (10). PEEP is valuable not only to prevent the lungs from atelectasis formation and to treat hypoxemia during OLV; more importantly, as part of a protective ventilation strategy (11) it may decrease cyclic alveolar collapse and reopening (fig. 1).

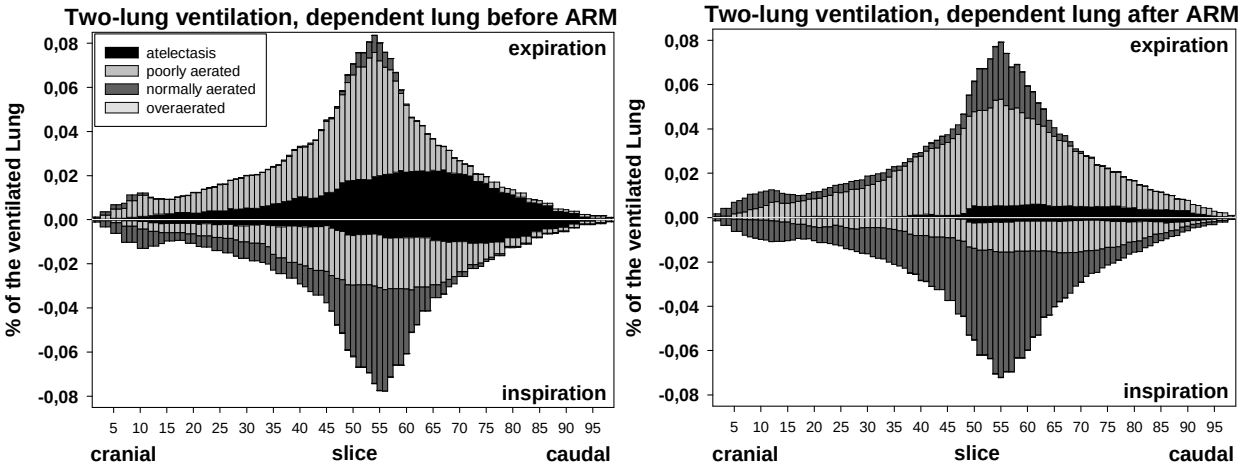

Figure 1. *A single alveolar recruitment maneuver (ARM, 30cmH_2O) followed by PEEP application (5cmH_2O) was sufficient to reduce the amount of atelectasis by 60% in ventilated pigs (V_T=10mL/kg). The figure presents the mean slice-wise distribution of overaerated, normally aerated, poorly aerated and atelectatic lung tissue in CT scans before and after ARM.*

Cyclic tidal recruitment and atelectrauma during OLV

OLV results in increased cyclic recruitment and de-recruitment of the alveolar units suggesting increased shear stresses with extensively elevated transmural pressures. Shearing and stretching have been detected as key factors in initiating an alveolar injury. The highest tidal recruitment is found in the most dependent and basal regions of the lung (12) whereas accompanying overstretching may occur at the boundaries of atelectatic, poorly, normally aerated tissue (fig. 2).

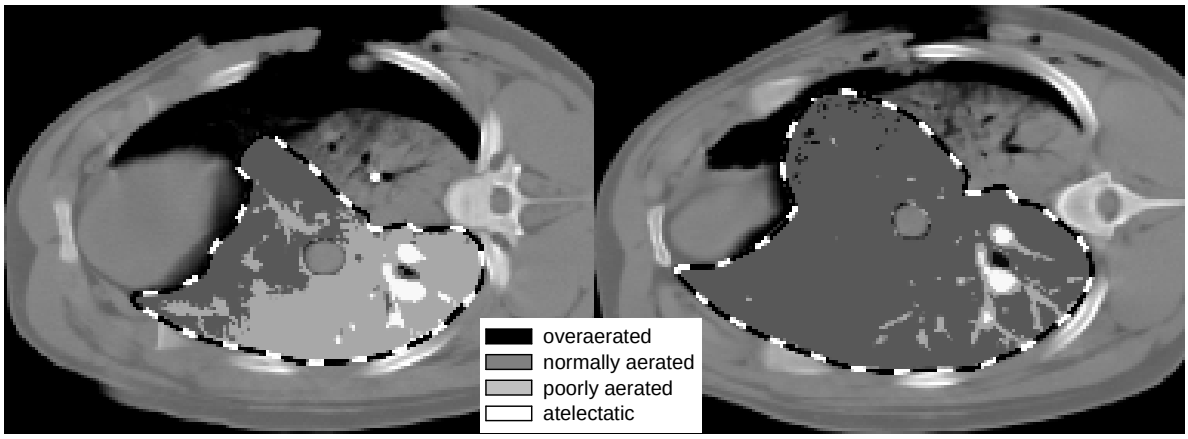

Figure 2. *Increased tidal recruitment indicated by decreased atelectatic/poorly aerated lung regions and increased fractions of normally aerated tissue in a representative transversal CT slice of a pig undergoing OLV (V_T=10mL/kg). The cyclic recruitment can be estimated by comparison of the gas/tissue content between expiration and inspiration.*

Effects of different tidal volumes during OLV

The use of relatively high tidal volumes during OLV has been shown to be associated with impaired prognosis after thoracic surgery (4). Accordingly, the reduction of tidal volume revealed significant effects on the alveolar release of pro-inflammatory cytokines after OLV and in the postoperative course (13). Low-tidal volume ventilation may further protect the ventilated lung from increased tidal recruitment during OLV (fig. 3).

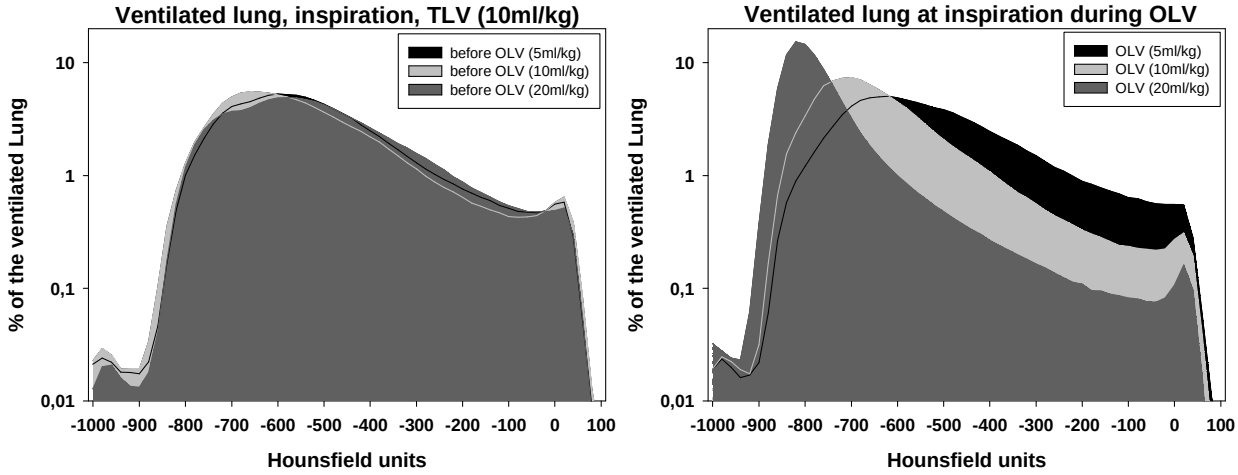

Figure 3. *OLV with V_T as used during two-lung ventilation (TLV, 10mL/kg) or even higher (20mL/kg) resulted in a shift of the radiological lung density to regions with increased gas content in a pig model of OLV. In contrast, OLV with half V_T (5mL/kg) did not impair the lung density distribution as compared with TLV before OLV and did also not increase cyclic tidal recruitment in the ventilated lung during OLV.*

Alveolar and systemic immunomodulatory effects of anesthetic drugs during thoracic surgery

OLV may induce epithelial damage and expression of pro-inflammatory mediators in the alveoli of the ventilated lung. The immune response was attenuated by volatile anesthetics (desflurane) as

indicated by decreased alveolar expression of pro-inflammatory cytokines (14). TIVA with propofol resulted in higher alveolar cytokine concentrations and in increased alveolar granulocyte recruitment. Recent experimental data revealed that the use of the volatile anesthetic desflurane not only attenuated the release of alveolar mediators but also decreased the expression of systemic pro-inflammatory cytokines as well (fig. 4). Like other halogenated anesthetics desflurane may have protective effects on mechanical forces during OLV. Furthermore, it may modulate granulocyte recruitment and neutrophil activation suggesting protective effects on OLV-induced lung injury (fig. 4).

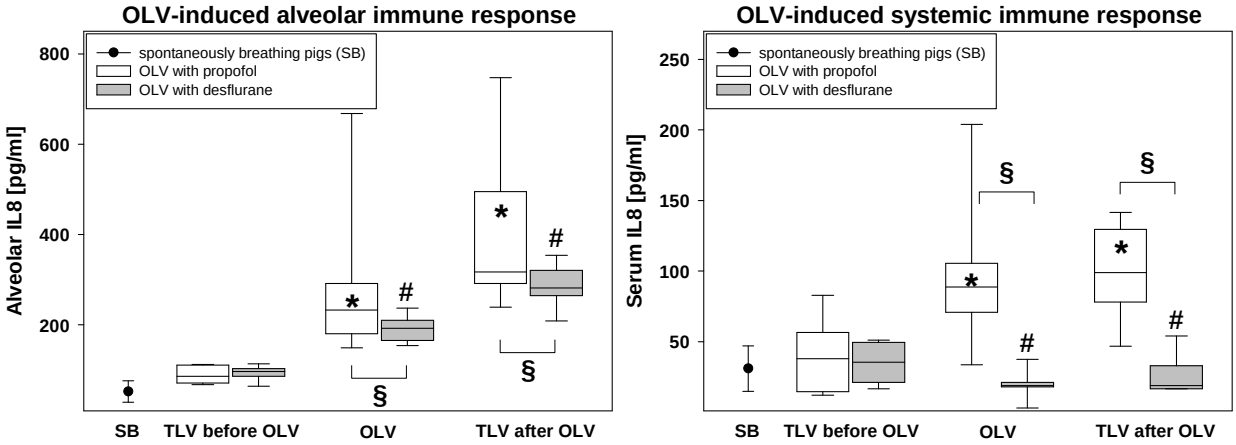

Figure 4. *OLV with V_T=10mL/kg induced expression of pro-inflammatory IL8 in the alveoli of the ventilated lung as well as in the peripheral blood of pigs in a time-dependent manner. Data are presented as medians and interquartile ranges; * indicates differences within pigs receiving propofol; # indicates changes within pigs receiving desflurane. § indicates differences between both OLV groups.*

Postoperative pain therapy

Sufficient pain therapy is essential to minimize complications after thoracic surgery. Systemic application of opioids remains the gold standard, however, thoracic epidural or paravetrebral analgesia using local anesthetics and opioids may provide superior analgesia during the first three postoperative days. Beside sufficient pain relief, TEA offers beneficial effects such as attenuation of cardiac, respiratory and gastrointestinal complications and positive effects on immune function and the coagulation system (15).

Summary

Primarily, anesthetic management during thoracic surgery has to provide optimal surgical conditions and has to protect the ventilated lung from deleterious consequences of pathological processes in the other lung. Thoracic surgery in geriatric patients is considered to be a risk procedure in terms of increased postoperative pulmonary morbidity, resulting form pathophysiological consequences of OLV. Therefore, the major challenge during OLV is the preservation of sufficient pulmonary gas exchange despite age-related physiological changes and high morbidity, and to protect these patients from adverse effects of OLV.

The OLV-induced lung injury may be attenuated by lung protective ventilation approaches including repetitive alveolar recruitment maneuvers, application of sufficient PEEP after ARM and by reduction of tidal volumes (4–6mL/kg) with subsequently decreased airway pressures (P_{AW}<30cmH_2O). While the restrictive intraoperative fluid management (<10mL/kg·h) and sufficient postoperative pain therapy are established procedures in thoracic anesthesia, the administration of volatile anesthetics, early recovery from mechanical ventilation, spontaneous breathing and the use of alternative ventilation modes should be considered to minimize postoperative pulmonary morbidity in the elderly.

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