The role of anaesthesia and enhanced recovery in the future of thoracic surgery

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Abstract: The development of enhanced recovery after surgery (ERAS) for thoracic surgery has created new challenges for the anaesthetist. The preoperative phase is critical not only to identify high-risk patients, but to optimise organ function. An anaesthetic is required which adequately suppresses the surgical stress response, the mainstay of ERAS, but also promotes rapid recovery with minimal side effects. Locoregional anaesthesia is the key. The use of a non-intubated, spontaneous breathing technique may confer some benefits. Effective analgesia is essential to allow early postoperative mobilisation and to reduce complications.

Keywords: Anaesthesia; enhanced recovery; lung resection; sub-xiphoid; video-assisted thoracoscopic surgical (VATS)

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Introduction

The importance of early ambulation after surgery to reduce complications was highlighted as far back as the 1940s (1,2). Enhanced recovery after surgery (ERAS) was developed in the 1990s to decrease postoperative morbidity by suppressing the stress response to surgery, consequently leading to improved patient outcome, reduced hospital length of stay and potential cost savings (3-5).

The main components of ERAS in thoracic surgery include preoperative optimisation, minimally invasive video-assisted thoracoscopic surgical (VATS) technique, standardised anaesthetic approach with multimodal analgesia, and early postoperative mobilisation with physiotherapy (6,7). An effective ERAS programme requires a multidisciplinary approach and the role of the anaesthetist is paramount throughout the perioperative period (8,9). The ultimate goal is to achieve day case surgery for lung resections (10).

Preoperative assessment

The main goal of the preoperative phase is the identification of high-risk patients, and optimisation of risk factors and organ function prior to surgery. In thoracic surgery, the preoperative efforts are specifically directed towards cessation of smoking, identifying and treating malnutrition, improving physical activity, and augmenting lung function. Physical inactivity, poor lung function and smoking are all important risk factors for complications after thoracic surgery (11).

Patient selection

Accurate risk prediction based operative mortality, perioperative adverse events and postoperative dyspnea, is recommended by the Society for Cardiothoracic Surgery in Great Britain & Ireland (12). Significant predictors of prolonged hospital length of stay after lung resection

include advanced age, performance status, insulin-dependent diabetes mellitus, renal dysfunction, cigarette smoking and percentage predicted forced expiratory volume in one second (FEV_1) (11). Cardiovascular risk can be assessed using the American College of Cardiology/American Heart Association 2014 guidelines on perioperative cardiovascular evaluation for noncardiac surgery (13).

Optimisation

Smoking cessation prior to surgery is paramount, as continued smoking is associated with an increased risk of postoperative complications such as pneumonia, myocardial infarction and stroke, and a higher 30-day mortality (14).

The use of pulmonary rehabilitation, a core component of the management of individuals with chronic respiratory disease, can improve lung mechanics and exercise capacity prior to lung resection surgery (15). This may translate into favourable clinical outcomes, with increased six-minute walking test (6MWT) distance and force-generating capacity of skeletal muscle. Exercise training optimises functional state by increasing FEV_1, decreasing symptoms and improving quality of life, leading to a reduction in postoperative morbidity and mortality (15-17).

Malnutrition, common in oncologic patients, is associated with muscle weakness, impaired wound healing and immune dysfunction, resulting in delayed recovery and prolonged length of stay. Preoperative screening for malnutrition allows appropriate treatment for 14 days prior to surgery, if required (18,19). Preoperative fasting of liquids should be limited, and the administration of carbohydrate drink two hours before surgery is recommended (19,20).

Patient education and counseling is a vital component of the preoperative period. Management of patient expectation and addressing any issues prior to hospital admission can improve psychological wellbeing, reduce postoperative pain and assist in fast-tracking (21,22).

Intraoperative management

The intraoperative anaesthetic management is comprised of several key components, but is influenced by the surgical approach. The advent of uniportal VATS technique may confer some benefits in terms of reduced postoperative pain, and the subxiphoid approach allows bilateral procedures to be performed through the same surgical incision (23-25).

Anaesthetic agents

The choice of anaesthetic drugs remains contentious. During one-lung ventilation (OLV), inhalational anaesthetic agents (IAA) have been shown to stabilise the endothelial glycocalyx and hence reduce the local inflammatory response and the risk of acute lung injury (ALI) (26). However, IAA are not without side-effects: they can increase the incidence of postoperative nausea and vomiting (PONV), compared to propofol total intravenous anaesthesia (TIVA) (27), and their suppression of natural killer (NK) cells may increase the risk of metastasis or cancer recurrence (28,29). At present, with the conflicting evidence in thoracic anaesthesia (30), there does not appear to be any benefit of TIVA over IAA (31,32).

Neuromuscular blockade (NMB) is typically used to facilitate endotracheal intubation. Prevention of residual paralysis at the end of the procedure is essential to promote fast-tracking. Neuromuscular monitoring is recommended and NMB reversal is required when train-of-four (TOF) ratio is less than 0.9, with either an acetylcholinesterase inhibitor or sugammadex (33). Aggressive prevention of PONV, using a multimodal approach, is recommended (34).

Analgesia

Multimodal perioperative analgesia is the mainstay of ERAS. A combination of paracetamol, non-steroidal anti-inflammatory drugs (NSAIDs), opioids, local anaesthetic (LA) agents, NMDA antagonists and gabapentinoids should all be considered (7). However, intraoperative opioids should be used with caution. Expression of μ-opioid receptors is increased in human lung cancer, and in animal models' opioids have been shown to stimulate cancer progression and metastasis, leading to reduced survival (35-38). Opioid-sparing or even opioid-free anaesthesia is feasible and may also help to reduce early postoperative opiate-related side effects, such as nausea & vomiting, hyperalgesia and acute tolerance (39). Although ketamine has the advantage of attenuating opioid-related hyperalgesia (40), its deleterious effects include depression of NK cell function, potentially promoting cancer recurrence (41).

The use of locoregional techniques is to be encouraged. As well as attenuating the surgical stress response, a fundamental element of ERAS, they have been shown to reduce postoperative morbidity (42). In addition to their anti-inflammatory action, amide LA drugs also

promote NK cell function, with the potential to inhibit the generation of metastases (43-45). Thoracic epidural analgesia (TEA) has traditionally been viewed as the gold standard, but paravertebral block (PVB) has been shown to provide equivalent analgesia, with fewer side effects (46). The development of newer plane blocks (serratus anterior plane block and erector spinae plane block) may prove to be equally efficacious alternatives (47,48). For the sub-xiphoid approach, a subcostal transversus abdominis plane block may provide adequate analgesia (49).

Ventilation

Lung protective strategies are important to reduce ALI and postoperative pulmonary complications. During OLV, best practice recommendations include a reduced tidal volume of 4–6 mL/kg; positive end-expiratory pressure (PEEP) titrated to individual lung compliance; intermittent recruitment manoeuvres; regular bronchial toilet; and adjustment of respiratory rate to achieve an adequate minute ventilation, with permissive hypercapnia tolerated (8,26,50). The use of pressure-controlled ventilation may confer some benefits over volume-controlled ventilation (51,52).

Alongside the evolution of minimally invasive surgery, anaesthesia has developed non-intubated techniques to reduce the adverse effects of tracheal intubation. Spontaneous breathing, with a surgically-induced pneumothorax, decreases lung inflammation caused by positive pressure ventilation, reduces postoperative pulmonary complications, avoids the risk of residual NMB, and expedites recovery (53-55). Such procedures can be carried out in awake patients under epidural anaesthesia (56).

Fluid balance

The goal of perioperative fluid management is to achieve euvolaemia, maintaining organ perfusion, but avoiding fluid excess and accumulation of extravascular lung water. Intraoperative crystalloid administration should be limited and intravenous colloid boluses used to replace significant blood loss. Goal-directed fluid therapy using minimally invasive monitors may be beneficial. Total fluid balance should not exceed 20 mL/kg in the initial postoperative 24 hours (8,57,58).

Temperature

Maintenance of normothermia is essential. Inadvertent perioperative hypothermia, defined as core temperature less than 36 ℃, is associated with increased intraoperative blood loss and transfusion requirements; reduced metabolism of anaesthetic drugs with subsequent delayed recovery; increased postoperative adverse myocardial events; poor wound healing with a higher incidence of surgical site infection; and depression of immune function, which may increase the risk of cancer recurrence (41,59-61). Monitoring core body temperature is now standard-of-care management, and the use of forced-air warming devices and warmed intravenous fluids is recommended to maintain normothermia (61).

Postoperative care

Rapid recovery is promoted by early mobilisation, effective analgesia, pulmonary rehabilitation and appropriate chest drain management. Patients should be mobilised as soon as possible following surgery and supervised ambulation is encouraged. Regular chest physiotherapy improves ventilation and aids clearance of secretions. Normal diet can be recommenced in a timely fashion (62-64).

Post-thoracotomy pain may contribute to atelectasis, leading to hypoxemia, pulmonary infection, and permanent alveolar damage. Continuation of the intraoperative multimodal analgesic approach to provide effective postoperative pain relief can reduce complications (65). With the introduction of liposomal bupivacaine, single-shot LA techniques can now provide analgesia for up to 96 hours (66,67).

In the postoperative period, the presence of chest drains is a significant source of pain and can impede patient mobilisation (68). Early chest drain removal is feasible and is associated with reduced pain, improved FEV_1, and shorter hospital length of stay (68-70).

Conclusions

The growth of ERAS in thoracic surgery has created new demands on the thoracic anaesthetist. Patient selection is key to identify those suitable for fast-tracking and preoperative optimisation is essential. The challenge is to provide an anaesthetic which both suppresses the stress response to surgery, the mainstay of ERAS, and utilises short-acting agents to enhance rapid recovery, whilst avoiding drugs which may promote cancer recurrence. Effective locoregional techniques appear to offer the optimal solution. Minimally invasive surgical methods in

conjunction with less invasive anaesthetic approaches, such as the non-intubated spontaneous breathing technique, all facilitate an expeditious recovery for the patient (71).

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Footnote

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jovs.2018.09.11). The authors have no conflicts of interest to declare.

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