



Clinical guidelines on perioperative management strategies for enhanced recovery after lung surgery

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Introduction

The concept of enhanced recovery after surgery (ERAS) was first developed in Denmark in 1997 by Dr. Kehlet (1). ERAS is designed to optimize perioperative management, improve patient prognosis, reduce complications, shorten hospital stay, and lower cost (2-5). In recent years, this multi-disciplinary and multi-modal perioperative rehabilitation concept has been widely applied in open and endoscopic procedures including colorectal surgery (6,7), gynecological surgery (8,9), liver surgery (10,11), breast surgery (12,13), urologic surgery (14,15), and spinal surgery (16-18).

Advances in thoracic surgery, especially the popularization of minimally invasive techniques, have dramatically expanded or changed the concept of surgical treatment (19-21). Early recovery from thoracic surgery is now routine (22-24). In Jan 2019, the European Society of Thoracic Surgeons published guidelines for enhanced recovery after lung surgery (25) on: preoperative counselling, nutritional screening, smoking cessation, rehabilitation for high-risk patients, avoidance of fasting, carbohydrate loading, avoidance of preoperative sedatives, venous thromboembolism prophylaxis, prevention of hypothermia, short-acting anesthetics to facilitate early emergence, regional anesthesia, nausea and vomiting control, opioid-sparing analgesia, euvolemic fluid management, minimally invasive surgery, early chest drain removal, avoidance of urinary catheters, and early mobilization after surgery.

The lung is a unique organ in that it receives the total cardiac output and acts as a giant filter for systemic venous blood (26). It is, in addition, an open organ; through the airway, the alveoli interact with the surrounding environment. Due to its unique anatomy and physiology, the lung is susceptible to injuries caused by a variety of harmful endogenous and exogenous factors (27). Perioperative risk factors and treatment measures can result in damage to the lungs, which in turn can lead to postoperative pulmonary complications (PPCs) (e.g., atelectasis and pneumonia) and pleural complications, affecting early and long-term recovery (28-30), and accounting for up to 84% of all

deaths (31). Perioperative airway and protective ventilatory management in lung surgery are an important part of ERAS (32,33). Given the circumstances, we have established clinical guidelines based primarily on an extensive literature review, with discussion and consensus focused on the issue of perioperative airway management for enhanced recovery following lung surgery. In addition, we will briefly review other perioperative measures designed toward the goal of ERAS for thoracic surgery.

Preoperative preparations

Patient education

The content of preoperative patient education includes the patient's self-preparation, introduction to relevant policies, postoperative bed arrangement, postoperative cooperation, postoperative symptom management, and individualized guidance (34). Patient education helps patients to better understand their disease, the objectives behind their treatment, and the nursing care they will receive. It also supports patients in dealing with the psychological impact of their disease and helps them to adapt to life as an inpatient. Furthermore, it encourages patients' cooperation throughout their treatment, including at the surgery and postoperative rehabilitation stages. It also enables patients to master methods and techniques for improving lung function and promoting lung rehabilitation, builds their confidence in surgery, and promotes self-care awareness and postoperative rehabilitation. Both patient satisfaction and the patient experience in healthcare institutions are improved by patient education (35-37). In addition to verbal instructions, patients should be provided with written and multimedia material illustrating care plans.

Patient engagement

Patient engagement directly impacts outcomes such as patient adherence, patient self-management, preventing behaviors, satisfaction with care, and lower health care costs. The Patient Health Engagement model

(PHE-S[®])—which can identify and monitor patients' level of psychological readiness to be an active player in their healthcare team – could be a reliable instrument to facilitate and support the active engagement of patients in their own care (38-40).

Smoking cessation

The relative risk of PPCs in smokers is 1.4 to 4.3 times that of nonsmokers. Even in patients without chronic lung disease, smoking is a risk factor for increased PPCs (41). Quitting smoking is one of the most effective ways to prevent PPCs. It has been found that if patients quit smoking for more than 4 weeks before surgery, PPCs can be reduced (42). However, in patients with a smoking index of ≥ 800 cigarette-years, smoking cessation even 2 weeks before surgery will not lower the risk of PPCs (43,44). Compared with non-smokers, smokers have significantly longer hospital stays after lung surgery, along with significantly higher mortality (45).

Preoperative pulmonary function assessment

The pulmonary function test (PFT) is affected by ventilation and airway obstruction (46,47). It helps the surgeon to comprehend the nature, severity, and reversibility of the lung disease and thus facilitates the prediction of surgical outcomes and pulmonary complications, as well as the selection of the appropriate type of surgery and its extent (48). The forced expiratory volume at 1 sec (FEV1) can independently predict the risk of lung resection. Patients with abnormal results of PFT (especially low FEV1) are at a higher risk for PPCs. These patients should undergo adequate preoperative examinations to identify the surgical risks and appropriate measures that need to be taken to improve the patient's lung function and decrease the risk of PPCs (49-52). Some patients may benefit from optimization of lung function by pulmonary physician. The peak expiratory flow (PEF)—also called peak expiratory flow rate (PEFR)—refers to the maximal rate that a person can exhale during a short maximal expiratory effort. It mainly reflects the strength of the respiratory muscles and the patency of the airway but may also reflect the ability to cough, which is highly effort-dependent. Decreased PEF is seen in patients with obstructive or restrictive ventilatory disorders. If PEF is < 320 L/min, the patient can have trouble expelling phlegm after surgery, which may result in lung infection (29).

Preoperative airway management

For high-risk patients, airway preparation, including drug therapy combined with physical rehabilitation, should be performed before surgery. Commonly used drugs include antibiotics, glucocorticoids, bronchodilators, and mucolytic agents. The combinations of nebulized drugs (e.g., budesonide inhalation suspension + terbutaline sulfate solution for inhalation + acetylcysteine solution for inhalation) help to reduce airway hyperresponsiveness and prevent perioperative airway complications (53-55).

The recommended physical rehabilitation measures—which include chest physiotherapy and incentive spirometry, climbing stairs, and power-based cycling—help to increase lung capacity and improve lung function (56). The intensity and duration of training are based patient-dependent. They should not increase the patient's disease burden but should be sufficient for the patient to gain the benefits of regular exercise. Besides FEV1, the diffusion capacity of carbon monoxide in unit time (DLCO) is also important and when levels are low, CPET (cardiopulmonary exercise testing) evaluation should be carried out to identify those who require rehabilitation.

Preoperative anti-infective treatment

Pulmonary bacterial infections should be treated rationally with antibiotics. Elective surgery should be postponed until the acute respiratory infection is resolved. For patients with excessive sputum production, surgery should not be performed until 2 weeks after the sputum volume is reduced. For patients with accompanying chronic respiratory diseases, antibiotics can be used 3 days before surgery (57). In patients with a history of heavy smoking or moderate to severe emphysema, pathogenic bacteria may colonize mouth, pharynx, and upper and lower respiratory tracts before surgery, which can increase the incidence of postoperative pneumonia. Perioperative antibiotic prophylaxis can reduce pulmonary complications.

Intraoperative management

Anesthesia

The selection of anesthesia method and drugs should be made according to the following principles: effectiveness in sedation, analgesia, and muscle relaxation; rapid postoperative awakening and recovery; satisfactory blockage of adverse nerve reflex after surgery; small anesthesia-

induced trauma and few disturbances to respiration/circulation; and fewer complications (20,58,59).

During the operation, target-oriented personalized volume management is the best way to reduce postoperative acute lung injury (33,60). Circulation should be kept stable, and high or low blood pressure should be avoided. Correctable causes of arrhythmia, if present, should be identified. The airway must be kept patent ensure proper ventilation (61,62). Intraoperative application of bronchodilators can reduce bronchospasm (63-65).

Thoracic surgery usually requires a double-lumen endotracheal tube for one-lung ventilation. The goal of one-lung ventilation is to ensure adequate surgical exposure while maintaining adequate oxygenation, and to avoid acute lung injury (66,67). At present, lung-protective ventilation strategies comprise: low tidal volume (4-6 mL/kg), positive end-expiratory pressure (PEEP), and lung recruitment (68). Among them, low tidal volume is the most important mode, and tidal volume and PEEP should be dynamically adjusted according to the patient's respiratory mechanics. Lung recruitment refers to the process of reopening the atelectatic lung unit by increasing the transpulmonary pressure. At present, PEEP titration is recommended to replace lung recruitment maneuvers. In addition, low-to-moderate inhaled oxygen concentrations (FiO_2 , 30% to 50%) should be used when satisfactory oxygen saturation is achieved (69).

Surgical management

Careful preoperative planning optimizes the surgical procedure and thus helps to shorten the operative time and reduce surgical trauma (24,70). Minimally invasive techniques are recommended; in particular using incisions that limit muscle trauma and reduce postoperative pain are preferred (71). In an open approach, muscle-sparing thoracotomy (preserving the latissimus dorsi and serratus anterior muscles) may be considered as an alternative to posterolateral thoracotomy. Excessive stretching, squeezing, and/or twisting of lung tissue must be avoided. Two "maximizations" should be achieved during the surgical treatment of lung cancer: maximization of the removal of the tumor and maximization of the preservation of the lung tissue (72). The integrity of the thoracic cage also needs to be maintained and major nerves such as the recurrent laryngeal nerve, phrenic nerve, and vagus nerve should be protected (73). Preservation of the long thoracic or accessory nerves is also important. Care must also be

taken to prevent and reduce the occurrence of pulmonary air leaks (74). The negative venous pressure should be carefully managed to prevent air embolism (75). To avoid fat embolism, treatment of fractures should be gentle (76).

Postoperative treatment

Postoperative airway management and pulmonary rehabilitation

Aerosol inhalation should be initiated early after surgery to humidify the airway and be directly applied to the airway mucosa (77). The combination of glucocorticoids (e.g., budesonide inhalation suspension 2 mg per time, 2-4 times per day) with bronchodilators (e.g., terbutaline sulfate inhalation solution, 5 mg per time, 2-4 times per day) relieves airway inflammation (78). Active coughing and expectoration should be encouraged (79); meanwhile, mucolytics (e.g., acetylcysteine inhalation solution, 300 mg per dose, 2 times per day) can dissolve and dilute the mucous sputum in the airway, thus facilitating expectoration and reducing the risk of postoperative complications (80). In addition, it has been found that multidisciplinary collaborative airway management strategies including incentive spirometry, coughing and deep breathing, oral health care, patient (and family) education, early and ambulation at least 3 times daily, and raising the head of bed (by $\geq 30^\circ$) can substantially reduce the incidences of pneumonia and unplanned intubation in the postoperative period (81,82).

Rational use of analgesics

Along with physical rehabilitation, postoperative pain management plays a key role in achieving the rapid improvement of lung function (83,84). Effective postoperative analgesic measures can promote early diaphragmatic movement, coughing, and expectoration, thereby reducing damage to lung function and decreasing pulmonary infections (85). According to the ERAS principles, opioids should be avoided if possible, and epidural, paravertebral, or erector spinae plane anesthesia with ropivacaine with or without an opioid is recommended. Both are superior to intravenous morphine and can significantly improve postoperative lung function (86) without central nervous depression. Analgesia by means of other techniques such as transcutaneous electrical nerve stimulation (TENS) or serratus anterior plane (SAP) block may be used as a technical adjunct to control severe

pain (87-90). Furthermore, pain can be alleviated by early removal of chest drain (91).

Early ambulation

In 1949, Leithauser acknowledged that early ambulation was essential for the well-being and safety of patients undergoing surgery (92). In addition, he proposed that early mobilization can save lives by avoiding protracted hospitalization, thus preventing many fatal complications, and that rehabilitation exercise early after surgery is an important means to prevent PPCs (93,94). To achieve early ambulation, postural adjustments and shoulder movement can be increased (95). It was also found that using a pedal exerciser while sitting alone on or after the second postoperative day can significantly reduce the incidence of postoperative respiratory tract infections and dyspnea and significantly shorten hospital stays (96). Although there have been no confirmed differences between the exercise capacity or lung function of patients who commenced early postoperative physiotherapy protocol and those who started later, patients with operable cancer seem to benefit from early exercise programs in terms of fatigue reduction (97). However, the effect of an increased postoperative activity level in the early postoperative lung surgery must be further evaluated (98).

Expert opinion

How about the application of ERAS in the surgical treatment of lung cancer in your center? Has a treatment system been formed?

Expert opinion 1: Alan D. L. Sihoe

In my old hospital in Hong Kong, a program for patient care after lung cancer surgery was already used since the early 2000s. In 2007, to complement the increasing use of VATS, I designed a new Clinical Pathway for use with patients receiving lung cancer surgery by VATS (another way of saying 'fast track' or ERAS). It significantly improved our outcomes, but was still not good enough. In 2010, I further updated our hospital's Clinical Pathway to make it more detailed, more user-friendly, and more easily audited. This improved results further and allowed variance analyses to enhance quality assessment. In 2014, I transposed the Clinical Pathway for use in our new hospital in Shenzhen, and further adapted it to the needs of modern Uniportal VATS and incorporated advances such as routine use of digital chest drain technology. As you

can see, we not only have a very long-established traditional of comprehensive ERAS management, but we have constantly improved it over time.

Expert opinion 2: Andrea Droghetti

Yes, we have. We are organizing with our administration the pathway in hospital.

Expert opinion 3: Antonio D'Andrilli

ERAS application is not standardized for all patients, but most of ERAS recommendations are currently applied.

Expert opinion 4: Calvin Ng

Yes, we have a post-operative clinical pathway that we should follow unless clinical condition of the patient deviates from the expected, allowing early mobilization, targeted physiotherapy, optimization of pain-control and resumption of oral diet. We also have pre-operative clinic with the patients 2 weeks before surgery to educate them about the operation, what to expect, how to cooperate with physiotherapy during hospital stay, ensure smoking cessation, optimizing blood pressure and diabetes control, avoiding chest infections prior to surgery, improving their diet etc.

Expert opinion 5: Luca Voltolini

Yes, we have applied ERAS protocol to the surgical treatment of lung cancer by VATS.

Expert opinion 6: Majed Refai

ERAS is already adopted in my center. I began with TEAM education in 2017.

Expert opinion 7: Paolo Ferrari

In 2017 we started a FAST TRACK protocol assessment for surgical lung cancer management. After one year of experimental application, according to ERAS guidelines produced by Italian VATS Group, we introduced an enhanced recovery trail for all patients underwent VATS lobectomy for NSCLC.

Expert opinion 8: Roberto Crisci

In my center a course of treatment has been formed, however practical-administrative reasons have so far prevented the clinical start.

Expert opinion 9: Anthony M. H. Ho

Kingston General Hospital does not have a formal ERAS for thoracic surgery, but anesthesiologists already practice

most or all of the principles of ERAS.

Indwelling urethral catheter is routinely used after surgery in most patients with lung cancer. For patients with normal renal function before surgery, should early removal of indwelling catheter be recommended to relieve postoperative discomfort?

Expert opinion 1: Alan D. L. Sihoe

I disagree. A urinary catheter is NOT routinely used in lung cancer surgery. A long time ago, we would insert a catheter only if we required accurate assessment of a patient's fluid balance during and after surgery (e.g., in pneumonectomy or complex operations). However, we have NOT used urinary catheters in any lung cancer surgery patients now for over 12 years.

Expert opinion 2: Andrea Droghetti

When we use the cath, we remove the day after surgery.

Expert opinion 3: Antonio D'Andrilli

Urethral catheter is generally not used in patients undergoing major lung resection in our Institution.

Expert opinion 4: Calvin Ng

We do not routinely place urinary catheters in our lung resection patients. Most straight forward major lung resection cases finish within 2–3 hours. For complicated cases with expected prolonged operating time, or cases with expected significant blood loss, or cases of patients with poor cardiac function we would place a catheter. Occasionally, patients without catheter have urinary retention in the post-anesthesia recovery room, and we would catheterize once (meaning catheterize to drain urine completely then remove) to relieve the retention.

Expert opinion 5: Luca Voltolini

Yes. Our protocol includes the removal of indwelling urethral catheter between 12 and 48 hours after surgery. Again, this is true for all VATS lobectomies in which we don't use the epidural catheter.

Expert opinion 6: Majed Refai

I agree that early removal is recommended.

Expert opinion 7: Paolo Ferrari

The indwelling urethral catheter should be avoided in patients without renal impairment or other urinary tract

pathologies. We strongly recommend the discharge of the urethral catheter in the early postoperative, after a clamping test.

Expert opinion 8: Roberto Crisci

Yes.

Expert opinion 9: Anthony M. H. Ho

Foley catheters are removed routinely the next morning after surgery unless there is an epidural. For women with an epidural, Foley is removed 1–2 days after surgery. For men, Foley is removed 1–2 days after surgery but for elderly men with an epidural, it could be 2–3 days after surgery to coincide with the withdrawal of epidural analgesia.

Placement of indwelling chest tubes is associated with postoperative pain and can inhibit breathing. Is it feasible to use a single chest tube instead of two after routine anatomical pneumonectomy? When do you think of a single chest tube should be used and when should two chest tubes be used?

Expert opinion 1: Alan D. L. Sihoe

We have not used 2 chest drains in any lung cancer surgery patients for over 15 years. In any standard lung cancer operation, I cannot see any situation where I would ever use 2 chest drains. (I only use 2 drains sometimes after complex empyema surgery—but that has nothing to do with lung cancer).

Expert opinion 2: Andrea Droghetti

We use always only one chest tube, never two.

Expert opinion 3: Antonio D'Andrilli

Single chest tube is used in most major lung resections at our Institution. Single tube is always used after minimally invasive procedures and after pneumonectomy.

Expert opinion 4: Calvin Ng

In routine segmentectomy, lobectomy and pneumonectomy, we usually place only one chest drain. We may occasionally place 2 drains if we expect the post-operative drainage to be very heavily blood stained, but for pneumonectomy we always place one drain. For operations such as decortication for empyema, we would routinely place 2 drains.

Expert opinion 5: Luca Voltolini

Our ERAS program suggests using just one pleural drainage

(28/30 Fr) after pulmonary lobectomy. We consider to place a second tube in case of bilobectomy, significant postoperative air leak (very rarely) or when a significant postoperative bleeding is expected (in case of coagulopathy or when an aggressive anticoagulation therapy is required).

Expert opinion 6: Majed Refai

Single chest tube is sufficient even after pneumonectomy. We use only single chest tube.

Expert opinion 7: Paolo Ferrari

In our Institution we mean pneumonectomy as a complete removal of an entire lung, where a single chest tube is suggested for a correct pressure balance inside the residual chest cavity, until the chest tube removal. Regarding anatomical lobectomy or segmentectomy, a single chest tube is recommended, possibly with the new concepts of draining system (spiral drain-smart drain). We reserve double chest drain for those procedures where an extensive pleural decortication or chest wall surgery are associated.

Expert opinion 8: Roberto Crisci

The current surgery always provides for the use of only one drain, except in exceptional cases.

Expert opinion 9: Anthony M. H. Ho

After open pneumonectomy, one chest drain is inserted. We don't do VATS for pneumonectomy in Kingston. Rarely ever have 2 chest drains.

Some studies have shown that chest tube can be safely removed after surgery for lung cancer even if the amount of daily pleural fluid production is larger (up to 450 mL/24 h). What are the routine criteria for chest tube removal in your center?

Expert opinion 1: Alan D. L. Sihoe

In our ERAS protocol of 2010, our removal criteria are: (I) no air leak for 24 hours; (II) 200 mL over last 24 hours or less; (III) no evidence of pleural space infection. However, in our 2014 protocol, we have revised this to: (I) air flow on digital system <40 mL/min for 6 hours with no 'spikes'; (II) 200–300 mL over last 24 hours (but this can be higher at the discretion of the surgeon); (III) no evidence of pleural space infection. This protocol is for my fellows/residents to follow. But in reality, if I am doing the ward round myself, I often remove with even higher daily fluid

outputs.

Expert opinion 2: Andrea Droghetti

Under 300 mL/24 h.

Expert opinion 3: Antonio D'Andrilli

Threshold generally used for chest tube removal at our Institution is 3–4 mL/kg.

Expert opinion 4: Calvin Ng

In terms of volume of drainage, we use a figure of 200 mLs/24 hours as the cut off for drain removal. I believe that perhaps the volume in relation to body size or weight is a more sensible measurement. For example, 450 mL/24 hrs in a 50kg patient is different to the same volume in a 100 kg patient. There are other considerations too, for example, if the drainage fluid is heavily blood stained then we would tend to keep the drain longer even if drainage volume is below 200 mLs/24 hrs. We also look at the drainage volume trend over the past few days, and the chest radiograph to see if we need to shift out the drain to release basal collection.

Expert opinion 5: Luca Voltolini

We remove the chest tube when the fluid drainage/day is less than 4–5 mL/kg, considering that it sits within the range of physiological daily pleural fluid filtration.

Expert opinion 6: Majed Refai

We remove chest tube if daily fluid production is less than 400/24 h, if the patient is stable with normal chest X ray and acceptable HB.

Expert opinion 7: Paolo Ferrari

According to our program, we remove the chest drain in patients underwent lobectomies or segmentectomies, when a not bloody or chylous pleural fluid <4 ml/kg have been collected in the last 24 hours. Moreover, no air leaks or a digital air leak quantification <20 mL/min must be respected.

Expert opinion 8: Roberto Crisci

I prefer to remove the drain for a quantity of serum <200 mL/h.

Expert opinion 9: Anthony M. H. Ho

Chest drains are removed if drainage is 300 mL/24 hours. We consider over 300 mL/24 h excessive and chest drain is

usually kept in.

There are guidelines recommending that, for patients at high risk of VTE after surgery, continuous use of low-molecular-weight heparin for up to 4 weeks may be considered for long-term prevention. Is it feasible in clinical settings? Can physical prevention alone achieve the same effectiveness after such patients are discharged?

Expert opinion 1: Alan D. L. Sihoe

It is common knowledge (though not well documented in the literature) that Chinese patients have much lower risk of VTE than Caucasian patients. Therefore, those international guidelines may not be so suitable for Chinese patients. Over the last 20 years, we do not routinely use LMWH for any Chinese patients (we only use if patients have a known history of previous VTE). We use leg compression during surgery, and then TED stockings after surgery until patients are mobilizing well. Patients are fully mobile by the time of discharge, so we advise that patients can stop using TED stockings provided they ensure adequate mobilization after discharge. With this protocol, I have witnessed only 2 cases of VTE over the last 15 years.

Expert opinion 2: Andrea Droghetti

We use LWM Heparin for 2 weeks after discharge in high risk pts.

Expert opinion 3: Antonio D'Andrilli

In our opinion, due to early mobilization of patients in ERAS pathways, the postoperative period of LMW heparin administration can be shortened.

Expert opinion 4: Calvin Ng

Many of our patients with malignancy, and some with limited mobility or obese are the populations at high risk of developing VTE events. Some studies have shown lower incidence of subclinical DVT or PE when patients are given low-molecular-weight heparin in the early post-operative period, but not translating into VTE associated clinically significant event or mortality. Thus the real value of giving heparin is unknown. In our centre, we do not routinely give low-molecular-weight heparin to our lung surgery patients. We encourage early mobilization, and leg exercises even when they are lying on the bed or sitting out.

Expert opinion 5: Luca Voltolini

We believe that, for patients at high risk of VTE after surgery, continuous use of low-molecular-weight heparin for up to 4 weeks, is feasible and effective, even if there are no definitive data in the literature.

Expert opinion 6: Majed Refai

Physical prevention is not sufficient for oncological patients. We use single shot/day of low-molecular-weight heparin.

Expert opinion 7: Paolo Ferrari

Routinely use of LMWH in the first 30 days after surgery as VTE prevention is a feasible treatment in the clinical settings. Moreover, the physical prevention alone is patient dependent and should not fit adequately with a prophylaxis intent.

Expert opinion 8: Roberto Crisci

We use this scheme and do not believe that physical prevention alone can achieve the same efficacy.

Expert opinion 9: Anthony M. H. Ho

For patients at high risk of VTE (e.g., those with cancer), they are sent home to self-administer LMWH for 4 weeks. This is important as pulmonary embolus is usually fatal.

Who needs airway preparation before a lung cancer surgery? How long does airway preparation take and what are the criteria?

Expert opinion 1: Alan D. L. Sihoe

From a surgeon's perspective, we do not request any airway preparation for a standard lung cancer operation. If a patient is deemed to have a 'difficult airway' for intubation or if awake intubation is indicated, the in-charge anesthetist may use airway preparation as he/she wishes. However, this is an anesthetic—not surgical—issue, and hence it is not something that a surgeon would make the decision about.

Expert opinion 2: Andrea Droghetti

All patients start FKT when they start pathway and continue after surgery.

Expert opinion 3: Antonio D'Andrilli

Patients with severe COPD should undergo preop airway preparation. Two weeks of airway preparation are generally sufficient.

Expert opinion 4: Calvin Ng

Those patients with borderline pulmonary function, or low post-operative predicted lung capacity would be candidates for airway preparation. Patients with poorly controlled asthma or COPD are also candidates. We aim to optimize the high-risk patients for surgery to reduce respiratory complications.

Expert opinion 5: Luca Voltolini

We consider prehabilitation which includes aerobic training and respiratory exercises in patients with borderline respiratory function or exercise capacity. The median duration is 3 weeks, but no firm recommendations can be made on the exact nature of the intervention regarding frequency and duration.

Expert opinion 6: Majed Refai

All patients should meet the Physiotherapist at the moment of counselling and begin education before surgery. Severe COPD you have to optimize their treatment but you must not exceed 1 month to surgical treatment from the day of diagnosis. And repeat PFT and Chest Xray if necessary, otherwise the patients are not fit for ERAS (if they are > ASA 3).

Expert opinion 7: Paolo Ferrari

In our Institution all patients awaiting anatomical resections receive a respiratory physiotherapy assessment. According to preoperative PFTs and sputum collection microbiology results, antibiotics, glucocorticoids, bronchodilators, and mucolytic agents are administered. Patients with FEV1 <60% are followed by the physiotherapy department for a tailored rehab program before surgery.

Expert opinion 8: Roberto Crisci

I think patients with chronic bronchopneumopathies need to be prepared. This preparation must be at least 10 days before the intervention.

Expert opinion 9: Anthony M. H. Ho

When infection is identified, the case is postponed or the problem treated. Chest physiotherapy and incentive spirometry as alluded to in the text of this manuscript are also used perioperatively.

Should anesthesia with spontaneous ventilation be included in the ERAS process?**Expert opinion 1: Alan D. L. Sihoe**

I do use GA with spontaneous ventilation ('non-intubated'

GA) in some patients. However, I do this out of academic interest to explore its potential—NOT because I am convinced it has any advantages at all. The current evidence for GA with spontaneous ventilation is quite poor, as the few studies reporting on this technique have small cohorts, limited study designs, and/or other methodological shortcomings. I would conclude that there is insufficient data to suggest that GA with spontaneous ventilation should be included in any ERAS protocol at the present time.

Expert opinion 2: Andrea Droghetti

That's sure... non intubated thoracic surgery must be investigated.

Expert opinion 3: Antonio D'Andrilli

In my opinion there are still not sufficient data and evidences to include anesthesia with spontaneous ventilation in the ERAS process.

Expert opinion 4: Calvin Ng

There is probably sufficient evidence that in select patient populations, performing surgery with spontaneous ventilation could be beneficial, and can enhance recovery. However, I think we are far from putting it as a recommendation or essential part of ERAS, given the differences in local practices and skills. The concept of spontaneous ventilation could be included in the ERAS process.

Expert opinion 5: Luca Voltolini

No, or at least not yet.

Expert opinion 6: Majed Refai

Spontaneous ventilation (non intubated) may be included but we have to standardize the procedure.

Expert opinion 7: Paolo Ferrari

Although several studies report advantages of non-intubated thoracic surgery compared to general anesthesia with double lumen tube, the effect of spontaneous ventilation over surgical outcomes in lung cancer patients must be further evaluated, and should be avoided inside ERAS protocol.

Expert opinion 8: Roberto Crisci

Yes.

Expert opinion 9: Anthony M. H. Ho

No. Spontaneous ventilation is not possible in an open chest.

Conclusions

ERAS is a multidisciplinary collaborative process that integrates a series of effective measures. In addition to the inputs of surgeons, anesthesiologists, rehabilitation therapists, and nursing staff, it also requires the active participation of patients and their families. It is hoped that the consensus on the perioperative management, including preoperative preparations (e.g., patient education, smoking cessation, preoperative pulmonary function assessment and airway management, and anti-infective treatment), intraoperative management (e.g., anesthesia and surgical management), and postoperative treatment (e.g., postoperative airway management and pulmonary rehabilitation, rational use of analgesics, and early ambulation) could help to put existing knowledge into practice in perioperative management and encourage the wider application ERAS in lung surgery.

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Footnote

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