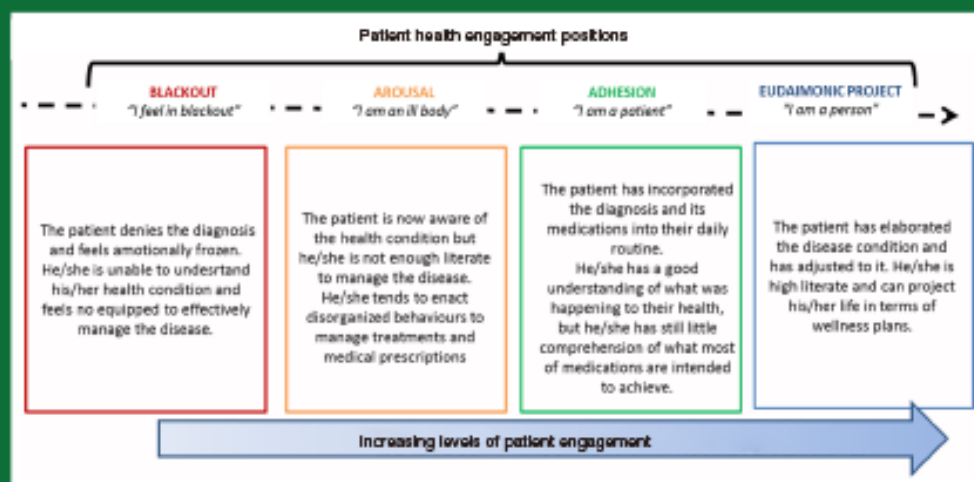# JOURNAL of THORACIC DISEASE

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FOCUSED ISSUE: Enhanced Recovery Pathways in Thoracic Surgery from Italian VATS Group

Guest Editors: Andrea Droghetti, Roberto Crisci

Patient health engagement positions

BLACKOUT "I feel in blackout"	AROUSAL "I am an ill body"	ADHESION "I am a patient"	EUDAIMONIC PROJECT "I am a person"
The patient denies the diagnosis and feels emotionally frozen. He/she is unable to understand his/her health condition and feels no equipped to effectively manage the disease.	The patient is now aware of the health condition but he/she is not enough literate to manage the disease. He/she tends to enact disorganized behaviours to manage treatments and medical prescriptions	The patient has incorporated the diagnosis and its medications into their daily routine. He/she has a good understanding of what was happening to their health, but he/she has still little comprehension of what most of medications are intended to achieve.	The patient has elaborated the disease condition and has adjusted to it. He/she is high literate and can project his/her life in terms of wellness plans.

Increasing levels of patient engagement

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The ERAS project for VATS lobectomy—the Italian VATS Group

The mission of the ERAS Group (Enhanced Recovery After Surgery Group), an active branch of the Italian VATS Group (www.vatsgroup.org), is to promote an upgrade of the current standard perioperative clinical practice after VATS lobectomy and to emphasize the assessment of patients' outcome.

This collaborative multidisciplinary Group was assembled by Andrea Droghetti and Professor Roberto Crisci in 2016 and is focused on multimodal perioperative clinical care: standardizing practices from different institutions and striving for excellence in clinical practice.

The Italian VATS Group was founded in 2013 and endorsed by Italian Society of Thoracic Surgery to promote and standardize the practice of VATS lobectomy among Italian thoracic surgeons. After 4 years of experience with the National Prospective VATS Lobectomy Registry, with nearly 6,000 cases enrolled, the ERAS Database was developed in order to share clinical data, improve outcomes through research and promote evidence-based practice.

This focused issue of the Journal will have an immediate didactic value in helping the multi-disciplinary team understanding the fundamental skills of ERAS and achieving success in ERAS for Thoracic Surgery.

This manual presents different experiences and "real-life" scenarios from around the world, although it also contains several protocols, focusing specifically on the anesthetic and surgical techniques, nursing, nutrition and metabolic response. It also includes a prospective data collection focused on ERAS.

We are confident that this issue may fill an existing gap by providing a major bibliographical tool and by facilitating the practice of ERAS.

As long as the Registry will give us more information and more experience emerges, further manuals on the topic of ERAS for VATS lobectomy will be published.

Last but not least, I would like to thank all the authors for their work and support in this first focused issue on ERAS in Vats Lobectomy.

Andrea Droghetti

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Preface to enhanced recovery after surgery

Often prefaces make you want to continue reading the book you would like to introduce as a mitral rite, but this does not depend (fortunately) on the preface. To avoid such unpleasant problems, in the dialogues with Leucos, Cesare Pavese himself wrote the preface expressing himself in a third person. Moreover, even when he came to Eugenio Montale to write a preface to Italo Svevo, his reading caused yawning.

However, writing the foreword to this Enhanced Recovery After Surgery (ERAS) Manual and Fast Track is full of joy because over the past 30 years there has been a Copernican revolution in operating techniques and postoperative patient care. The advances in technology have allowed numerous major surgical interventions to be performed with minimally invasive techniques, enabling patients to recover faster. These factors played a significant role in the emergence of a new era in the patient's perioperative operation. The ERAS protocol was born with the aim of ensuring, after surgery, an optimal recovery and early return to daily activities while maintaining physiological homeostasis. Among the benefits of ERAS, in addition to early discharge, we can enumerate the reduction of stress, reduction of complications and, therefore, finally, reduction in health expenditure. The critical elements of this approach have already been introduced in 1980 and have been applied by modifying perioperative care standards at the end of the last century. However, although the protocol is based on solid scientific bases supported by evidence-based medicine (randomised trial and meta-analysis), its spread in Italy is still slow.

For this reason, I am delighted with the forthcoming release of this Issue of the *Journal of Thoracic Disease* (*JTD*), which ends at the end of a long work within the VATS Group. Moreover, in this Issue, the various authors and collaborators could synthesise concepts and describe how to turn a protocol into reality. Today, ERAS is even more current: the world has changed and has become a virtual village where innovation, both thinking and doing, is increasingly demanded. Moreover, putting these items together in a consistent way to make a useful book is not simple: you must imagine it, look for ingredients, surgically erase the egoists (all that does not have to be read in the book). This is a manual for curious people. Moreover, we hope that the curiosity that has made him bring you to read it.

Roberto Crisci

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Enhanced recovery after surgery protocols in video-assisted thoracic surgery lobectomies: the best is yet still to come?

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Introduction

In the 1990s, a sequence of papers on fast-track programme in general surgery was published, showing a reduction of complications and the hospital length of stay (LOS). This knowledge is grown into a multidisciplinary tool usually known as enhanced recovery after surgery (ERAS) that assimilates numerous perioperative elements (ERAS protocols) (1). Presently, there are several official guidelines published by the ERAS Society for many specialities and several meta-analyses documented the benefits of ERAS. ERAS thinking involves a team of surgeons, anaesthesiologist, nurses, physiotherapists and dieticians with the aim to advance the quality of care by assimilating evidence-based knowledge into clinical practice (2-4). On the contrary, regarding thoracic surgery, up to now, there are no endorsed ERAS guidelines, and the papers supporting the benefits of modern perioperative management are partial. Most of the general principles used in other surgical discipline may be applicable. Nevertheless, the existing results on ERAS pathways compared with traditional perioperative management of patients undertaking video-assisted thoracic surgery (VATS) lobectomy for cancer is still under debate. In addition, in a systematic review to summarise the evidence of ERAS in lung resections, authors identified only a small number of low-quality comparative studies. Some non-randomised studies yield encouraging results suggesting that ERAS may reduce primary LOS and hospitalisation costs, but they should be interpreted considering several methodologic limitations (1).

Developments of enhanced recovery pathways in VATS lobectomies

VATS lobectomies are safe and useful as a typical operation for early-stage lung cancer regarding the postoperative clinical stay. The expansion of an ERAS program in thoracic surgery was fewer than other specialities. Nevertheless, ERAS decreased postoperative complications and decreased the LOS. ERAS highlights the complete change within a hospital (5) (*Table 1*). Members of a team should assess the protocol at unequal intervals, assemble data to analyse variances with hindsight and attempt to advance the care progression. Nevertheless, handling variance also necessitates ongoing determination and perseverance, and it remains uncertain the timing of meeting and the developments to realised. Variances are rarely analysed in healthcare organisations that have applied clinical pathways due to the difficulties in creating definitions, classifying variance, and handling technology. It is essential to define critical events of conformance and outcomes to resolve these data management difficulties, identifying the critical procedures, result criteria and outcomes. These actions comprise compliance with the clinical pathway, timeliness, and types of dissimilarities from the pathway. The developments and use of the clinical pathway vary among groups, and the management differs among groups. Therefore, beginning clinical guidelines that the evaluation of the value or practicability of clinical pathways should be achieved (6). In a prospective, randomised, controlled pilot trial included lung resections cared using either a traditional treatment or a fast-track protocol, the fast-

Table 1 Suggested interventions in an enhanced recovery protocols for VATS lobectomies

Suggested interventions
Preoperative
Diagnosis and treatment of anaemia
Optimisation of medical therapy
Maintenance of exercise capacity
Detailed assessment of patient's history, condition and calculation of the risk
Information about pathway care
Fasting minimised (fluids allowed <2 hours preoperatively)
Intraoperative
Protective ventilation
Fluid overload avoided
Extubation in operating theatre (if feasible)
One chest drain
Postoperative
Low threshold for chest drain removal
Early oral intake
Early aggressive mobilisation

VATS, video-assisted thoracic surgery.

track group fasted for only 2 hours (7). By conducting daily physiological assessments, it was identified the daily rehabilitation time as crucial after VATS lobectomies (8). ERAS preoperative assessment from anaesthesiologist aimed to recognise high-risk patients, with the objective of optimising them before VATS, and for planning postoperative management. Preoperative reduced functional capacity is recognised risk factors for complications following thoracic surgery. Smoking addiction, ischaemic heart disease, peripheral vascular disease and renal impairment will frequently be seen. However, some interventions, which may not be ERAS part, may be required in advanced chronic conditions (5). As a fast track, VATS has become a well-known technique in the treatment of lung cancer, the planning of pain management should be tailored. Epidural patient-controlled analgesia and intravenous patient-controlled analgesia achieved the comparable efficacy of pain control for fast-track VATS lobectomy (9). The chest drainage pain decreases in VATS due to early removal of this pain-inducing device. VATS drops the surgical trauma due to no rib-spreading instruments, and

smaller thoracotomy, with fewer drainage and, therefore, a smaller amount of fluid evacuation (10). It could be found in the literature some papers suggesting after VATS lobectomy the chest tube removal notwithstanding volumes of fluid <500 mL/day (11). Few patients developed pleural effusion requiring reintervention, and furthermost could be treated without hospital readmission and additional complications (11). In ERAS protocols, laboratory tests should be ordered when indicated, but routine use of tests may not be required. Although the length of hospital stays, postoperative testing, and the use of intensive care after VATS lobectomy has decreased, thoracic surgeons must pay attention to and further improve their outcomes. During these years, a minimalist approach was developed by some large volume groups (12). Chest roentgenograms in the recovery room and after drainage removal could be not necessary since the chest drainage is not an indication for a chest X-ray (12). Patients on the ERAS programme had a significantly reduced postoperative LOS and a better after a survey. It was calculated that ERAS project resulted in a net saving major than €235,000. The ERAS pathway has proven to be a safe perioperative management strategy without increasing postoperative morbidity or mortality (13). Even if used in elderly patients, ERAS protocols not increased the overall hospital LOS, and mean economic cost of treatment. The prevention of complications caused successful management of ERAS pathway. Clinical pathways are not a humble instrument in the management procedure without considerate the potential meaning or background of each step. Skill to predict variance is crucial to effective management while managing the variance disclosed by reviews is also indispensable. A new kind of global pathway was recognised as daily one-paged, continuous, multi-paged table with space for documentation along typical evolution. Also, collecting variance with the gateway method was applied in the early identification of critical conditions (6).

The "dark side" of ERAS pathways

As with the implementation of any change, there were barriers encountered during the implementation of ERAS program. There were safety concerns, concerns regarding having the appropriate staffing ratios to implement the program, concerns about patient compliance, and concerns about how the program would affect patients' pain. Perhaps the most formidable barrier to implementation of the ERAS principles in minimally invasive thoracic surgery program

was a concern for patient safety. When discussing barriers specific, it was described a lack of workforce and time as a barrier to implementation of ERAS principles. This issue was a barrier to implementation in our program as well. Overcoming this barrier required significant collaboration between hospital administrators and the leaders of the thoracic surgery team (7). A uniform approach to the perioperative care may yield benefits regarding reserve use and efficiency savings, also, to increase quality. Protocols that ensure reliable patient management lead to complications decrease and consequently overdue hospital discharge, enhancing the satisfaction of the patient. Selection and safety of patients are fundamental. It is probable that several thoracic surgery patients will be at high-risk for these protocols. A graded implementation process may be considered: fairly low-risk measures and patients first, then selected higher-risk patients after (14). On the contrary, it was recently demonstrated no benefit by the ERAS program on outcomes (complications, 30/90-days mortality, hospital LOS, and readmissions) (15). Therefore, ERAS recovery program elements may be insufficiently different from previous standards of perioperative care to confer detectable benefits. For patients undergoing VATS lung resection, it is possible that all patients now receive sufficient beneficial components of ERAS and that this should now be regarded as "standard" rather than "enhanced" care (15). The most significant progression in cost reduction will arise from the preoperative and intraoperative management standardisation, along with the previously recognised postoperative management. The lean process saves money and decrease variables removing fault and consequently improving quality (16).

Conclusions

In an era in which both patients and hospitals benefit from decreased hospital LOS, the ERAS techniques and interventions enable the patient to return more quickly to fully functional status while minimising many of the postoperative complications associated with thoracic surgery. In today's healthcare environment, ERAS protocols can push past traditional barriers to create innovative strategies designed to deliver the highest quality care most cost-effectively. Application of thoracic surgery ERAS protocols seems to decrease postoperative complications and hospital LOS. Useful ERAS application involves proper sustenance, multidisciplinary participation and appropriate instruction for all subjects involved. Highly standardised

management is of principal importance like the quick identification of not eligible patients. Nevertheless, we need for well-designed randomised clinical trials to provide the conclusive evidence about the role of the ERAS protocols in the VATS lobectomies.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Enhanced recovery pathways version 2.0 in thoracic surgery

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Enhanced recovery pathways (ERPs) after surgery is a multimodal plan of care based on the application of multiple standardized evidence-based elements with the aim to improve the perioperative patient experience and surgical outcomes. These standardized elements are not just limited to the postoperative period but refer to the preoperative phase and obviously the surgical procedure. ERP is based on the concept of "marginal gains", well known in sport. Applied in isolation, the individual elements may have not a great effect on the outcome, but when applied together they act synergistically (1).

The concept of ERP has been popularized in other specialties, particularly colorectal surgery, in which this practice has shown great benefits compared to standard care (2).

However, thoracic surgeons are used to the elements of ERP, even though these were not badged as such. Certain practices, such as fluid balance, pain management, early mobilization, postoperative rehabilitation, are used in many thoracic surgery centers since decades. Several years ago, Cerfolio and colleagues (3,4) for instance identified modifiable and non-modifiable factors, which could contribute to improve fast track rate. Among the modifiable factors, the most relevant were the management of chest tubes, pain control, and social support plans. In spite of the factors contributing to ERP are well embedded in the thoracic surgery practice, the literature on ERP in our specialty is scant (5). Only few studies tried to analyze the effect of a standardized practice on the outcome after lung surgery. These studies were inconsistent in the elements they used to define a fast track protocol. The findings were also inconsistent. In general, the application of standardized elements of care contributed to reduce hospital stay. However, inconsistent findings were reported in terms of

morbidity, mortality and re-admission rates (6-8).

In all specialties, minimally invasive surgery represents the most important element in an ERP program. Yet so far most of the studies in thoracic surgery failed to include patients submitted to video-assisted thoracoscopic surgery (VATS), mostly because they were conducted prior to the widespread use of this approach.

In a recent study, we were not able to find any difference in terms of morbidity, mortality and length of stay between patients submitted to VATS lobectomy before and after the introduction of a formal ERP program at our institution (9). The most likely explanation for this rather disappointing finding is that the majority of the key elements, which constitute ERP were already in place before the start of a formal ERP (i.e., use of a single drain, use of a digital drain system, similar pain management, postoperative rehabilitation, early oral feeding, etc.). The addition of few other elements such as the assumption of energy drinks before surgery to reduce the catabolic response or the use of warming blanket to prevent shivering and hypothermia among the others are unlikely to provide any benefits in a population who received most of the other ERP elements already although not in a formalized fashion. Finally, and probably most importantly, the study included only patients undergoing key-hole surgery. VATS is the key elements of ERP likely obscuring the effects of other elements when applied together with this approach.

Are we already in a post-ERP world? Are we thoracic surgeons so good that what our surgical colleagues of other specialties call "enhanced recovery" is for us "standard care" (9,10). The practices of pain control, fluid restriction, early as possible mobilization, physiotherapy are all widely adopted by most of the thoracic surgery centers since decades.

In order to improve even more the experience with care

of our patients we probably need to make a further step toward a higher level of perioperative care: an ERP version 2.0. Particularly in the face of an ever-increasing number of patients presenting with multiple co-morbidities and higher surgical risk and the advent of non-surgical lung cancer treatment modalities, we need to progress from a standardized, ready-made to a tailored surgical care modulated to the characteristics and preferences/values of the patients.

In this regard, the use of specific and prospective databases, like the one created by the Italian VATS Group, represent the essential element to identify and validate specific ERAS indicators for our specialty.

We need to move from the concept of outcomes to the one of values in healthcare (11). Value in healthcare is expressed by the equation quality over cost. Quality in lung cancer surgery is represented by longitudinal outcomes such as cancer specific survival and quality of life. When interpreted in this way, costs should not be limited to hospital costs, but include social costs. In other words, we need to shift our focus from myopic short-term results toward a more patient centric evaluation of efficiency. This should be the benchmark to evaluate our performance, the effectiveness of new technologies or lung cancer treatments, and finally of any process of care aimed at improving patient-centered values. This is what we mean for ERP version 2.

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Footnote

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A comprehensive protocol for physiokinesis therapy and enhanced recovery after surgery in patients undergoing video-assisted thoracoscopic surgery lobectomy

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Background: Video-assisted thoracoscopic surgery (VATS) lobectomy has recently been adopted as the gold standard surgical option for the treatment of early stage non-small cell lung cancer. Enhanced recovery after surgery (ERAS) is being progressively adopted in thoracic surgery to improve the postoperative outcomes. Even if the benefits of ERAS are universally accepted, to date a standardized and uniform approach has not been described in the medical literature. The Italian VATS group has recently proposed to include in the VATS lobectomy database a structured protocol for ERAS.

Methods: The ERAS section of the Italian VATS group is proposing a comprehensive ERAS protocol within the VATS lobectomy database, allowing the prospective collection of a dedicated set of data. Separate sections of the protocol are dedicated to different topics of ERAS. This study is specifically dedicated to the section of physiokinesis therapy. The medical literature will be extensively reviewed and a physiotherapy (PT) protocol of ERAS will be presented and discussed. A seta of structured clinical pathways will also be suggested for adoption in the VATS Group database.

Discussion: Pre- and post-operative adoption of an ERAS protocol in patients undergoing VATS lobectomy may promote an improved post-operative course, a shorter hospital stay and an overall more comfortable patients' experience. The mainstays of a physiokinesis therapy ERAS protocol are patients' education, constant physical and respiratory therapy sessions, and adoption of adequate devices. Although many studies have investigated the usefulness of physical and respiratory physiokinesis therapy, a comprehensive ERAS protocol for VATS lobectomy patients has not yet been described. The proposed ERAS platform, adopted by the VATS Group database, will contribute to a prospective data collection and allow a scientific analysis of the results.

Keywords: Physical therapy; respiratory therapy; enhanced recovery after surgery (ERAS)

Introduction

Enhanced recovery after surgery (ERAS) is a multimodal approach to perioperative care that includes specific pathways to promote an early recovery after surgical procedures. It focuses on maintaining an adequate pre- and post-operative organ function and on reducing the stress response following surgery. The cornerstones of ERAS are: preoperative counselling, optimization of nutrition, standardization of anesthetic and analgesic regimens, physiotherapy (PT) rehabilitation and early mobilization.

Video-assisted thoracoscopic surgery (VATS) lobectomy is the gold standard treatment for early stage, non-small cell lung cancer (NSCLC) in eligible candidates. However, this procedure may be associated, similarly as in other surgical operations on the chest, with the development of postoperative pulmonary complications (PPCs) such as atelectasis, pneumonia and pleural complications (1,2). These complications may have an impact on patients' early recovery after surgery and on their long-term quality of life. PPCs are one of the most frequent causes of postoperative mortality following pulmonary resections, accounting for up to 84% of all deaths (3).

In 1949, Leithauser *et al.* acknowledged that "early ambulation was essential for the well-being and safety of patients undergoing surgery" (4). In addition, he proposed that "early mobilization has proven to be able to save lives by preserving them from protracted hospitalization, thus preventing many fatal complications" (5). Unfortunately, bed rest has been historically adopted for its expected benefits derived from patient comfort (6,7). Today, even short-term immobility is widely recognized as a potential cause of many complications, including thromboembolic events (8). For this reason, some kind of motor and respiratory therapy after surgery of the chest has been adopted by most of the physicians of the thoracic surgical community, based on their benefit on patients (9-12).

PT is universally considered as a fundamental support; it may prevent the development of PPCs that may be associated with a significant clinical and economic impact; it may also contribute to prevent post-operative respiratory failure, as extensively reported in the literature (13-16), and to promote patients' recovery.

It is widely recognized that all patients should be included into a perioperative rehabilitation protocol after thoracic surgical operations. However, there is consistent heterogeneity on PT programs and the timing for their implementation (before and/or after surgery). Evidence on the effectiveness of PT is not homogeneous, probably because of the variability of the programs' contents and the quality of the design of the studies. In addition, there is still just a limited number of studies focused on the effectiveness of physical therapy in patients undergoing VATS lobectomy for lung cancer and, therefore, the evidence-based recommendations are scarce (17).

The aim of this paper is to provide a synopsis of a motor and respiratory PT protocol within the ERAS project promoted by the Italian VATS Group. This study proposes a guide for standardized treatment criteria and suggests an adequate timing and methodology in respect to each individual center expertise and resources.

ERAS and VATS lobectomy: what is the evidence?

The literature on ERAS for lung resections is very scant. A systematic review by Fiore and colleagues only identified six studies involving lung resections, and only one of them was a randomized trial defining fast track protocols and analyzing outcomes (18). The incidence of postoperative complications with the use of ERAS was reduced in one of the three studies. Two studies only evaluated the incidence of readmissions and reported discordant results: one showed no differences between ERAS and non-ERAS patients (19) and the other reported a 3-fold increase of readmissions in the fast-tracked patients (20).

These non-univocal findings are even harder to interpret given the fact that the majority of the studies on ERAS for thoracic surgery did not include patients undergoing VATS, but were retrospective analyses of series antecedent the wide application of VATS lobectomy.

Minimally invasive surgery is considered one of the mainstays of ERAS. In particular, compared to open surgery, VATS has shown to reduce pain, the incidence of complications, hospital mortality and length of stay (LOS); to improve functional recovery and the quality of life (21-26). The beneficial effects of VATS over open surgery are even more evident in high-risk patients (27,28).

Another recent retrospective, single-center study compared patients undergoing VATS lobectomy before and after the initiation of a formal ERAS protocol, without showing substantial differences in terms of early mortality rates and complications between groups. The possible explanation for this finding was that the pre-ERAS "standard of care" already included several ERAS components that

may have contributed to provide good outcomes to VATS patients (29).

It is matter of debate whether the inclusion of aggressive perioperative PT protocols would be effective to provide better outcomes, in particular for patients undergoing VATS lobectomies who typically present an uncomplicated recovery.

Accordingly, VATS itself is the mainstay of ERAS in thoracic surgery, even though it may mask the effects of other components of ERAS on patients' outcome.

Training and rehabilitation: acquiring targets

Clearance of bronchial secretions, chest expansion exercises, postural correction and shoulder range of motion are all exercises that are traditionally included in PT schedules. Technical advances in surgery and pulmonary PT are bringing new perspectives to rehabilitation for candidates to surgery. As reported in the literature, the perioperative implementation of traditional PT targets such as exercise training, combined or not with inspiratory muscle training (IMT) and intended as a recovery and a maintenance approach, suggested beneficial results (30,31). IMT has been widely studied in pulmonary rehabilitation programs especially in COPD patients (32,33). It has been demonstrated that IMT may provide clinical improvements through a better inspiratory muscle endurance and strength, reduction of dyspnea and better quality of life. In addition, respiratory muscle training displays better results compared to endurance training, and it can be easily performed at home with a specific device for inspiratory resistive breathing and threshold loading (34).

In order to prevent PPC, it is important to promote an adequate expansion of the lung and to remove bronchial secretions. Thus, the inclusion of deep breathing exercises with bronchial clearance and early patient mobilization within the PT program is of utmost importance.

A recent randomized control trial (RCT) investigated postoperative IMT in addition to breathing exercises and early mobilization in high-risk patients after lung cancer surgery, failing to show a significant difference in pulmonary function outcomes. Only a significant reduction in hypoxemia was observed in patient who underwent training. This is a unique study considering the postoperative effects and associated risks of IMT in patients undergoing lung surgery. The lack of significant results could be related to the low load level during IMT (35). Unfortunately, there are very few studies investigating respiratory muscle training in

surgical patients, particularly in pulmonary surgery, either preoperatively or postoperatively.

The mainstays of PT: where does evidence stand?

Preoperative conditioning

Preoperative PT is considered a mainstay in patients undergoing surgery of the chest, due to its preparatory efficacy, but there is a lack of knowledge about its actual impact (36). Many institutions provide pre-operative PT treatments, but the studies on their efficacy are surprisingly scarce and methodologically limited (37,38). Recent studies of preoperative pulmonary rehabilitation performed on surgical candidates showed a correlation between adherence to pre-surgical exercise and relative pulmonary function improvement (39-41).

Aerobic and muscle training

According to Pouwels *et al.*, preoperative exercise therapy (PET) may be a valuable approach to reduce PPC, mortality and LOS, to improve physical fitness and quality of life (42). Patients with severe COPD, who did not meet the inclusion criteria for lung surgery due to their reduced maximal oxygen consumption (VO_2max), were included in a four-week program of muscle training on a cycle-ergometer with a progressive load of their maximum work on CPET. Patients were also encouraged to practice breathing exercises and incentive spirometry (IS) twice a day. The aerobic capacity was significantly improved after training, reaching the inclusion criteria for lung surgery, despite the absence of lung function improvements.

Respiratory training circuit

A randomized, controlled clinical trial compared the effect of IS muscle training (started two weeks before surgery and maintained for three months) with a control group including patients who did not receive any respiratory training, and showed a significant improvement in FEV1 and FVC before surgery. This improvement became even more pronounced at the end of the observation period (43). Another study on COPD patients considered preoperative IS training in combination with a 5,000 step/day walk for two weeks prior to pulmonary surgery, with similar

results in terms of FEV1 and FVC. Candidates were also instructed about pursed-lip breathing, diaphragmatic breathing exercises, huffing and coughing for 15 min after nebulization with bronchodilation five times a day (44). A recent RCT examined the effect of a PT program (started one week before surgery and continued during all hospital stay), assessing a large number of variables (heart rate, performance in the six-minute walk test, FVC, FEV1, DLCO, oxygen arterial pressure, and carbon dioxide arterial pressure). In the treatment group, all the parameters were improved compared to the control group. PPC and LOS were both also significantly reduced in the intervention group (43). A smoking cessation program and the promotion of a healthy lifestyle, optimization of pharmacological therapy, nutritional counselling, stress management, bronchial hygiene and an exercise training program should be recommended in addition to other multidisciplinary interventions before lung-volume reduction surgery (45).

Immediate postoperative period

PT has been routinely used for a long time as a perioperative treatment (46) but has been only recently recommended by the European Society of Respiratory Society, the European Society of Thoracic Surgeons and the American College of Chest Physicians because of its proven efficacy in achieving functional benefits (47-50). More recently, a large non-randomized study investigated the effects of PT treatment, including deep breathing and early mobilization with a static cycling or treadmill, and confirmed the global reduction of pulmonary morbidity (51).

Several surgical centers are adopting a precise, measurable and achievable pathway in order to optimize cardiopulmonary function and improve surgical outcomes (52). Although it is difficult to verify patients' compliance to treatment, the achievement of target activities during the postoperative course may influence the outcome. PT treatment in the perioperative period has been the topic of many studies on lung surgery. Unfortunately, most of them showed methodological flaws, such as the absence of a control group.

Routine respiratory PT

One of the few RCTs including a control group that did not receive any respiratory PT program assessed the occurrence of PPC and the LOS in patients undergoing different types of lung resection with a thoracotomy approach. The authors concluded that routine respiratory PT seems to be unnecessary in such patients, even if the control group was not totally blinded towards PT, due to preoperative patient teaching on breathing, coughing and shoulder exercises, early ambulation and mobilization. Additionally, the exercise program in the treatment group had a limited duration and all patients included in this sample had an acceptable baseline pulmonary function (2). Another interesting study by Novoa *et al.* applied a propensity matched analysis on data made available by Varela *et al.* (14) that were of limited interest due to methodological flaws. Compared to Varela's conclusions, the authors showed, using a solid statistical analysis, that an intensive PT program significantly reduced patients' morbidity, avoided PPC, and improved the recovery process of patients undergoing lung surgery (51).

Respiratory devices

Routine PT programs in surgical patients are supported by scientific evidence, but some controversies still remain regarding the effective advantages of external respiratory devices, such as IS or the "PEP-mask" device, over traditional chest PT interventions. The inclusion of IS devices into a PT program has been questioned by randomized control trials in which patients undergoing lobectomy were divided into an "intervention" group (receiving PT and the volumetric IS device), and a "control" group (receiving PT only), both following a program lasting from pre-operatively until hospital discharge. The study concluded that PT with or without IS was equally effective in reducing PPCs and in improving pulmonary function (53). These findings were corroborated in a systematic review on the routine use of IS devices in patients undergoing thoracic surgery, which also stated that IS cannot replace or significantly improve the physiotherapist's work (54). The results reported in the literature about the use of other external devices within PT treatment protocols did not reach a definitive conclusion on advantages and costs.

Many devices are available for PT treatments. A systematic review compared the effectiveness of using simple devices (blow-bottle system and the "EP-mask") to promote breathing exercises with positive expiratory pressure (PEP) after thoracic operations. Depending on the type of respiratory technique, the PEP can be used either to increase or to reduce lung volume, but none of the studies

included in this review referred to the pressure applied or to the breathing pattern (55). Well-designed studies would be required in order to clarify the benefits of using these external devices in patients undergoing lung resection.

NIV therapy

A popular review of non-invasive ventilation (NIV) associated with chest PT after lung surgery showed that, in five "best evidence" trials, NIV improved the outcomes after lung resection (56). Perrin and colleagues applied NIV in 39 patients, 7 days before and 3 days after lobectomy. The 14 patients receiving NIV had a higher PaO_2 and lower $PaCO_2$. It was concluded that pre- and post-operative NIV may significantly reduce pulmonary dysfunction after lung resection (57).

Early mobilization and upper segmental exercises

Reeve *et al.* carried out a study in which all patients undergoing lung resection were stimulated to early mobilization and ambulation, frequent changes in position during bed rest, and performing upper limb and breathing exercises. The intervention group underwent a daily PT program, including actively-assisted shoulder mobilization. Patients were evaluated before surgery, on the day of hospital discharge, and one and three months after discharge. The intervention group had less shoulder and chest pain. The same results were observed one month and three months after discharge. Shoulder function was also significantly improved in this group, without significant differences in mobility, strength and quality of life (58).

A recent retrospective study considered 36 patients with non-small-cell lung cancer undergoing lobectomy who were encouraged to walk 4 hours after surgery, sit up on their beds 3.5 hours after surgery and maintain a sitting position for 30 min. Dressings were used to stabilize the chest tube and to minimize pain caused by movements. The results suggested that walking 4 h after surgery may achieve a better recovery of pulmonary function than conventional mobilization (walking the day after surgery) (59).

Another prospective, propensity-matched study clearly demonstrated that patients undergoing VATS lobectomy developed less PPC and had improved outcomes compared to patients undergoing thoracotomy. A better adherence to rehabilitation exercises during the perioperative period was noticed. In fact, patients were significantly more mobile at an earlier stage, required half of the PT and developed less

pulmonary and mobility issues (17).

Postoperative rehabilitation

Dyspnea, pain, fatigue and limitation in daily activities often occur in patients undergoing pulmonary surgery and may determine significant loss of their quality of life after discharge. Based on these considerations, many studies have focused on validating a PT program after-discharge. For example, one study defined a program where a supervised incremental cycle ergometer exercise provided 30 minutes of continuous stress at sub-maximal load achieved in CPET at baseline. Different exercises to fit abdominal muscles, upper and lower limb and inspiratory muscle were included, combined with educational sessions on nutrition, relaxation and stress management, principles of energy conservation, and breathing control. A PT program accelerated functional recovery in the interventional group, improvement of the symptoms of dyspnea and exercise tolerance (60). Lung function seems to recover in the first three months, while exercise tolerance grows slower, regaining a maximum after about one year. Long-term recovery of lung function and exercise capacities appear to have a different timing, because the recovery of pulmonary function is directly related to the progressive reduction of pain (61). Some studies support the beneficial effects of exercise training with a specific methodology, such as the one from Spruit *et al.* (31). An eight-week rehabilitation program through a non-randomized pilot study included patients undergoing surgical resection and adjuvant cancer therapy. The study was focused on the application of general exercise training preconized for COPD patients. None of the patient displayed an improvement of lung function after eight weeks, but conversely all showed an actual improvement in exercise capacity (37). A wide variety of patients with malignancy seems to have a beneficial impact from exercise programs, as described by McMillan *et al.* (62). Unfortunately, lung cancer patients are not included in any of these studies. Considering lung cancer, it might be expected that an improvement of physical training would be seen because, in parallel with other factors such as COPD and cardiac overload, pulmonary surgical resections also tend to result in a decreased exercise tolerance.

PT and analgesia: an issue of teamwork

Postoperative pain control is critical, together with PT,

to achieve a rapid improvement in pulmonary function. According to the principles of ERAS, analgesic drugs such as opioids are preferably avoided and analgesia with ropivacaine and sufentanil via thoracic epidural anesthesia (TEA) is preferred over intravenous morphine administration, resulting in a significant improvement of pulmonary function after lung surgery (63). Patients with epidural pain control showed a faster improvement in lung volumes, reducing the incidence of pulmonary complications such as atelectasis and pneumonia. Considering the disadvantages of TEA, including hypotension, urinary and bowel retention, respiratory muscle weakness, and neurological injury risk, other safe analgesic alternatives have been used, such as thoracic paravertebral block. A recent meta-analysis compared these two approaches, in terms of pain control efficacy and opioid consumption, and no differences were found except for a lower incidence of urinary retention and hypotension in the paravertebral block group (64). Analgesia by means of other techniques such as transcutaneous electrical nerve stimulation (TENS) (65) or serratus anterior plane (SAP) block (66) may be used as a technical adjunct to avoid or control severe pain. The concept of thoracic anesthesia and analgesia must be coherently conceived in an era of minimally invasive operations, which allow a consistent reduction of post-surgical pain.

ERAS—PT protocol in VATS lobectomy patients

A rehabilitation program is crucial for a successful recovery process, and should be coupled to the selection of appropriate outcome measures. The purpose of a "PT protocol in patients undergoing VATS Lobectomy" is to reduce the risk of complications in patients undergoing anatomic lung resections with a minimally invasive approach. There only are a few viable studies that may allow the definition of the best PT strategy, and none are focused on VATS. The "Italian VATS Group" is planning on a carefully designed clinical trial to apply ERAS to all patients accessing the VATS group national lobectomy database, in order to match operative outcomes with all the data acquired form the ERAS-PT Protocol. The results of the trial could outline potential surgery-related factors that may have an actual impact on respiratory and other physiologic parameters, independently from the patient's status.

The main respiratory complications occurring after surgery are:

- ❖ Compression atelectasis;
- ❖ Infections;
- ❖ Pulmonary embolisms;
- ❖ Acute bronchospasm;
- ❖ Retention of bronchial secretions;
- ❖ Respiratory failure (ultimately leading to ARDS).

The main non-respiratory complications occurring after surgery are:

- ❖ Bed rest syndrome (stiffness/joint blocks, shortening/muscle retraction, decubitus wounds);
- ❖ Central nervous system alterations (coma, hemiplegia/paresis, paraplegia, tetraplegia);
- ❖ Peripheral nervous system alterations (brachial plexus stretching, ulnar and median nerve compression, sacral plexus compression, Sciatic-Popliteal external syndrome).

Using a multi-disciplinary approach, the physiotherapist will inspect clinical patient data with the assistance of medical and nursing staff, if necessary. The following contraindications to PT will be taken into account, according the international clinical evidence and good practice:

- ❖ *Absolute contraindications*:
  - ◆ Active pneumothorax;
  - ◆ Inability to tolerate highest respiratory load.
- ❖ *Relative contraindications*:
  - ◆ Hemodynamic instability;
  - ◆ Acute asthma;
  - ◆ Acute pulmonary embolism;
  - ◆ Active airway or gastrointestinal bleeding;
  - ◆ Unstable coronary artery disease, unstable angina;
  - ◆ Gastroesophageal reflux;
  - ◆ Tracheoesophageal fistula;
  - ◆ Nausea or vomiting;
  - ◆ Intracranial pressure >20 mmHg.

Contraindications to motor PT (in addition to those indicated for respiratory PT):

- ❖ Severe respiratory impairment;
- ❖ Unaddressed atrial fibrillation;
- ❖ Severe hemodynamic instability;
- ❖ Dialysis in progress.

Preoperative approach

Key-points

- ❖ Motor and respiratory preoperative evaluations

(estimated session time: 30 minutes) are performed to improve patient recovery after surgery: by the physiotherapists during the pre-assessment visit, during the pre-operative Day Hospital admission (if applicable) or ultimately the day before surgery;

❖ An empathic approach to patients, a thorough explanation of the role of the physiotherapist and emphasis over the importance of motor and respiratory treatments in the perioperative period are mandatory;

❖ Physiotherapists attend routinely to surgeons' or anesthesiologists' rounds and patients' evaluation;

❖ The Rehabilitation Service Brochure and all operative devices are also delivered to patients at this time, together with a with accurate teaching about the PT program;

❖ A scoreboard should be used including a customizable checklist displaying information about disability or comorbidity such as: advanced age, obesity, malnutrition, cardiorespiratory diseases, neuromuscular disabilities, previous operations. It may be helpful to identify and to prevent possible complications after surgery;

❖ If no particular issue arises from the patient's assessment process, a single session of information, education and training will be performed. Conversely, physiotherapists will consider the opportunity of additional sessions in order to schedule specific treatments.

Aims

Physiotherapists should encourage an active and conscious participation of the patient and his relatives to the rehabilitation program. Information about the physiology of the chest wall and lungs are provided.

Methods

The patient will be informed about the effects of surgery on lung function. The role of bronchial clearance and early mobilization will be stressed: as soon as possible (immediately after awakening from surgery), the patient will be asked to sit at the bedside or in a chair. The patient is instructed on postural passages and on the protection of the surgical site using hands; the efficacy of cough is evaluated.

Physiotherapists will show how to perform deep breathing exercises: starting with deep tidal volume

breaths until reaching the total lung capacity (TLC), then maintaining a short apnea and performing one or two coughs or forced expiration technique (FET). The patient will learn the use of "volume-based" respiratory incentive devices (Coach and/or Voldyne) or "flow-based" respiratory incentive devices (Triflo) to allow a deep, open glottis inspiration. This preoperative assessment will give a baseline evaluation of the deep breathing capacity that will be available for comparison with postoperative data.

PEP, PEP-Bottle or Acapella devices are also presented, in order to prevent sputum retention and atelectasis. The activity of the inspiratory/expiratory chest musculature is explained, stressing to keep a good articular range of both thoracic and scapular crawlers with a traditional PT.

The importance of a good peripheral oxygenation is also emphasized by suggesting active limb exercises. A more appropriate ventilation mechanism can be pursued by stretching the inspiratory accessory muscles, together with muscles relaxation techniques.

Postoperative approach

Key-points

❖ The treatment must be carried out postoperatively between 4 and 12 hours after recovery form general anesthesia. The estimated session time is 30 minutes, from 2 up to 3 daily sessions;

❖ Physiotherapists will fill a postoperative evaluation sheet based on chest examination, respiratory pattern evaluation, recognition of parameters (HR, RR, NIBP, possible signs of hypoxia and hypercapnia) and taking into account biochemical data, ABG, chest X-ray, therapeutic and monitoring prescriptions;

❖ The rehabilitation program defined in the preoperative assessment will be followed by a physiotherapist;

❖ A modification of the clinical status may require extra-protocol rehabilitation measures, due to standard functional mobilization impairments.

Aims

The rehabilitation Criteria are focused on adequate pulmonary ventilation, through the recruitment of lung segments with atelectasis and bronchial secretions washout. Recovering an optimal articulation and stimulating an early walking and daily life activity is also essential. Patients'

relatives should also be involved in the rehabilitation exercises and in the entire process of care.

Methods

All the steps of the protocol may be modified according to individual clinical outcomes. For example, a longer duration of chest tube drainage, obstructive persistent bronchial secretions, pain from coughing or mobilization, hypo mobility, fatigue and desaturation, should induce quantitative and qualitative adjustments (according to multidisciplinary discussion with the surgeon or anesthesiologists).

The rehabilitation program will provide progressively growing goals of care. The physiotherapist will perform the techniques that he believes to be most effective in achieving defined targets. For motor PT, a target ≥80 meters at least twice a day, independently or with walking aid will be adopted. For respiratory PT, the evaluation of the recovery of pulmonary volumes is performed with the use of flow or volume respiratory devices.

The protocol is summarized in *Figure 1*, starting from postoperative day zero (POD 0) to the following sessions, until patient discharge from rehabilitation service.

Physiotherapists will set up self-treatment program aimed to restore balanced and symmetric costal-diaphragmatic kinetics (cautious solicitation of upper and lower rib expansions, in supine or seated decubitus). Therefore, the program will be focused on avoiding stiffness and reduction of muscle strength (working mainly on the scapula fixator muscles: latissimus dorsi, serratus, rhomboid and trapezium, through active-assisted cervical spine/back/lumbar PT). The patient will be spurred to perform exercises alone, in between rehabilitation sessions with the physiotherapist, and to report the results on a personal scoreboard sheet as in *Table 1*.

PT service discharge and self-treatment program

The patient concludes the hospital rehabilitation treatment when he is able to walk and to perform self-treatment exercises, possibly without assistance and possibly without oxygen therapy, without evidence of residual complications or disabilities. PT treatment goals are: walking ≥80 meters or ≥20 minutes at least 3 times per day; realigning respiratory capacity with pre-operative values. The patient continues with a personal self-treatment

program received from the physiotherapists on the day of PT service discharge. Daily routine should be recorded on the personal scoreboard sheet as in *Table 1*.

Discussion

In our opinion, the ERAS-PT protocol should be individually designed according to the patient's needs, considering all the issues related to surgery for lung cancer. The schedule of the treatment should be divided into three different phases according to the process of surgery: pre-operative, post-operative and maintenance. During the pre-operative treatment, the attention is dedicated to promoting a healthy lifestyle, respiratory expansion exercises, and bronchial hygiene. The role of patients' compliance to PT is a mainstay for a successful rehabilitation across all the three phases of the treatment, in order to reduce PPCs and hospitalization. Exercise training plays an important role to improve cardiopulmonary load, and may allow to consider for surgery even candidates with poor VO2max (67). The postoperative PT aims to promote a faster recovery through maximal inspiratory maneuvers, coughing and mobilization exercises of the upper and lower limbs, postural changes and shoulder impairment (68). In this phase, PT is focused on balancing the transition between the preoperative and the maintenance treatments, because as soon as the pain is reduced, the pulmonary function recovers. Patients' attitude to exercise may take longer to improve, mostly in patients who still have to undergo co-adjuvant therapies. This is another reason to stress the importance of an early mobilization approach, such as early ambulation or mobilization supported by static cycling and treadmill. Mobilization is considered the most critical step of a PT program and the one with, prospectively, the most productive outcomes.

A possible limitation of the ERAS rehabilitation program for pulmonary surgery is related to the physical limitations hindering patients from walking (for example, the severity of disease, worsened clinical conditions, ventilation, sedation). However, in some institutions, even ventilated patients are encouraged to walk to improve their outcome (69,70): an extreme and not easily reproducible trail.

One interesting message emerging from the literature emphasizes the idea that pre- and post-operative motor and respiratory PT may benefit from a synergistic effect in terms of reduced morbidity, improved functional capacity

1st session (POD 0)	Incremental treatment (following sessions)				PT target	
					Motor	Respiratory
Clinical evaluation and physical inspection	Continue daily				Assisted walking: 80 meters or 20 minutes ≥3 times per day	Functional recovery: alignment with preoperative baseline respiratory capacity
Vital signs: SpO$_2$ >88–90% (O$_2$ supply if needed)	Record vital sings and any changes to oxygen supply during activity (SpO$_2$ >80–90%)					
	Evaluation of self-treatment					
Bed or chair mobilization to favor chest verticalization and chest expansion (otherwise according to surgeon's requests)	Erect mobilization and assisted walking; previous assessment of clinical conditions; pain control; functional capacities	Out of bed/chair ≥45 minutes ≥3 times per day Assisted walking ≥10 minutes ≥3 times per day	Progressive weaning from assistance/ support during walking	Recovery and conditioning to simple daily activities with increasing walking time/distance (up to 80 meters or 20 minutes ≥3 times per day)		
Head/neck and trunk exercises to promote comfort and avoid pain development	Segmental and global mobilization					
Scapular crawler and upper limbs mobilization, with attention to the chest tube side						
Active/assisted lower limbs mobilization						
Respiratory exercises with/ without incentivator (e.g., volumetric/ flow respiratory incentivator: 10 cycles per hour)	Assisted cough or FET					

Figure 1 ERAS—PT summary scheme. Read horizontally. ERAS, enhanced recovery after surgery; PT, physiotherapy.

and better overall outcomes in patients undergoing lung resection. Conversely, unimodal treatments lose the beneficial impact on post-surgical pulmonary complications and length of hospitalization (71,72). Therefore, considering the inherent economic costs, programs of PT intervention based on a robust scientific evidence are required.

All the "Italian VATS Group" participants will be asked to adhere to this ERAS-PT protocol for all patients who

may tolerate the rehabilitation approach. All PT data will be collected into the National VATS Group Database. The prospective analysis on this data should help defining which is the best and safest PT treatment in patients undergoing VATS lobectomy, and understanding the best exercise trails, devices and timing of intervention. The results of this study will be provided on behalf of "Italian VATS Group" after an adequate follow-up period.

Table 1 Daily exercises data record

Item	Day 1			Day 2			Day 3			Day 4			Day 5			Day 6		
	AM	PM	Evening	AM	PM	Evening	AM	PM	Evening	AM	PM	Evening	AM	PM	Evening	AM	PM	Evening
Walking (mts./mins.)																		
Shoulder and back exercises (mins.)																		
Respiratory exercises (num. repetitions/best result)																		

mts., meters; mins., minutes; num., number.

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Footnote

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Enhanced recovery after thoracic surgery: patient information and care-plans

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Abstract: Many studies have confirmed that the implementation of enhanced recovery after surgery (ERAS) protocols has the advantages of reducing the potential complications after thoracic surgery and the length of hospital stay. The ERAS program involves a multidisciplinary team, aimed at integrating evidence-based knowledge into clinical practice in order to reduce the patient's stress response to the surgical procedure and improve the response to stress, guaranteeing a combination of better outcomes and cost savings. All this would not be possible without the improvement of minimally invasive surgical techniques, progression of anesthesia, pain control, and careful patient preparation. In this setting, a preoperative personal counselling may play a key role to reduce stress, fear or anxiety and improve the morbidity of patients, enabling them to achieve functional and psychological compensatory mechanisms more quickly. Preoperative patient counselling, performed using verbal, written or multimedia materials, is crucial in order to achieve the goal of the ERAS project: making the patient a potentially active participant and the main character of his recovery, able to positively impact himself throughout the surgical and healing process. This report is aimed at evaluating patient information and care-plans in thoracic surgery, reviewing the available evidence on ERAS pathways, and demonstrating our ideal program as discussed and shared among the Italian Thoracic Surgery Units accredited in the video-assisted thoracic surgery (VATS) group.

Keywords: Enhanced recovery after surgery (ERAS); thoracic surgery; patient information; care-plans; video-assisted thoracic surgery (VATS)

Introduction

Lung cancer is the leading cause of cancer-related mortality worldwide, despite improvements in diagnosis, staging and treatment (1). However, an increasing number of studies have confirmed that the enhanced recovery after surgery (ERAS) protocol, introduced in the late 1990s by Kehlet (2), has the advantages of reducing the morbidity and mortality rates, emphasizing the quality, rather than speed of recovery (3). The concept of ERAS, first adopted in open colorectal surgery, has been established in many surgical disciplines, thus, also involving the thoracic surgical population that has undergone both the open and video-assisted thoracic surgery (VATS) approaches (4,5).

The ERAS program involves a multidisciplinary team and aims to integrate evidence-based knowledge into clinical practice in order to reduce the patient's stress response to the surgical procedure and improve the response to stress (6). In this way, as reported by many authors (3), all these

benefits may result in the twofold guarantee of better outcomes and cost savings.

Considering the multidisciplinary approach, many professional figures are needed: surgeons, anesthesiologists, nurses, dieticians and physiotherapists.

To date, there are several official guidelines published by the ERAS Society formed in 2010; however, the studies documenting the feasibility and potential benefits of ERAS in general thoracic surgery are still limited. Therefore, the Italian Thoracic Surgery Units accredited by the VATS Group, including our center, started focusing their attention on this field, discussing and sharing operative protocols and goals during periodic meetings.

Although we previously reported that the clinical pathway of care adopted in our center was able to reduce the hospital stay and improve quality (7), the introduction of new evidence based medicine and clinical guidelines has led us to change our protocols of care, which are actually in continuous evolution.

This report aims to evaluate patient information and care-plans in thoracic surgery, reviewing the available evidence on ERAS pathways and identifying the ideal program potentially adoptable in clinical practice.

Patient information

Numerous studies have suggested that a more anxious patient has a poorer outcome in terms of length of hospital stay and complications (8), demonstrating a correlation with prolonged convalescence and postsurgical fatigue (PSF), defined as "unpleasant and distressing symptoms associated with a major impact on the patient's quality of life" (9).

In this setting, a preoperative personal counselling session may play a key role to reduce stress, fear or anxiety and improve the morbidity of patients, enabling them to achieve cardiovascular, respiratory, metabolic and psychological compensatory mechanisms more quickly.

Indeed, the clarification of the unknown and the detailed explanations of surgical and anesthetic procedures allow the patient to be a potentially active participant in his recovery, enhancing postoperative recovery and discharge.

Many studies (10-13) reported that not only the verbal instructions of procedures but also relaxation or preoperative education programs may impact on physiologic recovery, reducing the morbidity and PSF, and improving the wound healing response in surgical patients.

However, considering that not all patients desire to receive a full explanation of their recovery plan, the multidisciplinary team needs to balance the pros and cons of each aspect in order to not foster fear and anxiety (14).

Our program of counselling

In 2012 our Thoracic Surgery Unit (AOU Ospedali Riuniti, Ancona, Italy) began the process of creating a minimally invasive thoracic surgery program. We performed biportal VATS major resections according to D'Amico's technique until 2014, and successively we started to constantly adopt Rivas' technique (uniportal approach) to perform both major and minor surgery (15). As previously published (7), preoperative, intraoperative and postoperative standardized protocols were implemented aimed at fast tracking patients submitted to major lung resections.

Ideally patient counselling may be performed two weeks prior to surgery. At the first appointment, the whole team (surgeon, anesthesiologist, dedicated nurse practitioner and physiotherapist) informs the patient of all aspects of ERAS protocols, including surgical procedure, multimodal analgesia, nursing care, management of the perioperative period and planned discharge.

Considering that the success of any program depends on the education of the participants, we recommend providing information about the care-plans from the initial outpatient visit to the inpatient discharge using multiple modalities: verbal instruction, written materials (booklet) and web-based materials with audiovisual instructions.

Surgical care-plan—general education

The surgeon provides an explanation of the operation performed with minimally invasive techniques, its risks, benefits, morbidity, mortality, and potential alternatives. Patients are informed that due to their active participation in the healing process, the return to their preoperative functional status may be quicker.

Informed consent is obtained not only to absolve a law but also to establish the initial component of the physician-patient relationship. Indeed, for most patients who have undergone pulmonary resection, surgery is the first step in the process of having to face the disease, therefore their emotional state must be taken into account. Furthermore, the information transfer may be impaired by the patient's intellectual level, language barriers, learning disabilities, and cultural barriers. Considering all these factors, questions and discussions with the surgeon should be encouraged as an additional tool provided to the patients (along with

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written and web-based material, drawings).

Procedure-specific teaching (segmentectomy/lobectomy)

Patients are informed about the specific details of the surgical procedure, starting by position (lateral decubitus), incision length and tools used. After that, the surgeon provides some concept of the operative technique and potential postoperative complications (surgical and cardiopulmonary) or conversion to thoracotomy.

Patients are informed that the chest tube probably will be removed in the postoperative day (POD) 2 if no air-leak and <400 mL/day of pleural effusion are recorded by the electronic chest drainage system and the discharge will be scheduled in the POD3, if no complications have occurred (7). However, in rare cases, patients may be discharged home with the chest drain still in place and periodic ambulatory visits are needed until the chest drain removal. So, patients are taught to manage the chest tube at home during the perioperative period.

After discharge, we suggest a follow-up visit to perform chest X-ray 10 days later.

Chest physiotherapy care-plan

The incidence of pulmonary complications after thoracic surgery ranges from 15% to 37%, and several independent risk factors have been identified (16,17). However, the rate of many of the common complications (pneumonia, atelectasis) may be reduced adopting, just in the perioperative period, a physiotherapy care-plan with active patient involvement, allowing an improvement in pulmonary hygiene. Therefore, at the first appointment, physiotherapists should teach and educate the patients to perform the respiratory exercises (deep breathing, walking, coughing exercises and use of an inspirometer) in order to be more fit for the operation and to avoid alveolar and segmental collapse in the postoperative recovery. Uncomplicated patients should be treated by a physiotherapist once a day and followed-up until discharge; while patients with postoperative pulmonary complications (pneumonia, atelectasis) should be treated more than once a day. Both groups of patients are encouraged to continue the respiratory exercises during their hospital stay and for at least one month after discharge.

In addition, a physiotherapy care-plan facilitates early mobilization, allowing pulmonary hygiene and lung expansion. However, although the early ambulation is desirable for a prompt functional recovery, it often may result in difficulties due to the multiple attachment. Therefore, our team proposes displaying, in the ward's corridor, some instructional posters that indicate the walking distance in meters in order to motivate the patient to meet his daily walking goal. Although there is no specific scientific evidence on the minimum distance of patient walk required, a measurable distance may increase the patients' functional recovery and ease the way towards a successful surgical outcome.

If patients are current smokers, they are counseled to stop immediately. To date, the optimal time for smoking cessation has not been established and some authors even suggested an increase of pulmonary complications if cessation occurred just before surgery (18,19). However, we think that every effort should be made to encourage the patient to stop smoking.

Nursing care-plan

A dedicated nurse practitioner describes in detail what to do or not, what the observations are, nursing duties, wound care, early oral intake, postoperative pain management and hydric balance.

The nurse communicates to the patient if and when to stop anticoagulation/antiplatelet therapy before the surgery according to the medical decision.

Furthermore, patients at high risk for venous thromboembolism are informed that until discharge or full mobilization, they will wear a graduated compression stocking in association with anticoagulation, as suggested by the American College of Chest Physicians guide-lines (20).

During the initial visit, patients are instructed about preoperative fasting. As reported by the American Society of Anesthesiologist Task Force (15), clear liquids (such as water, fruit juice, clear tea, black coffee, etc.) and a light meal may be ingested for up 2 and 6 hours, respectively, before general or local anesthesia, procedural sedation and analgesia.

Patients are also informed that the removal of the urinary catheter is scheduled on POD1 if no complications have occurred and the peripheral venous catheter will be removed as soon as intravenous drugs are not needed.

Anesthesiologist care-plan—pain control

During the first appointment, the patient is informed about pain management both in the intraoperative and postoperative periods.

Indeed, the anxiety and the fear derived by the

expectation of pain, is one of the most alarming problems for a patient facing surgery. Counselling on the common technique of analgesia (narcotic/non-narcotic analgesics, paracetamol, non-steroidal anti-inflammatory drugs) should be provided, and the potential side effects (nausea, gastrointestinal dysfunction, headedness) should be discussed with the patient and his family members in order to reach the goal of the postoperative analgesia: pain control and prompt functional recovery.

In our VATS program, standardized analgesic and anesthetic regimens are used. Intraoperative pain control is guaranteed by infiltrating three intercostal spaces (IV, V and VI intercostal spaces) with ropivacaine 0.75% at the end of the operation under thoracoscopic vision.

Postoperative pain control is managed with intravenous (iv) paracetamol 1g (three times/day until POD2) and ketorolac 30 mg iv, if needed.

Postoperative pain control is monitored by the nursing personnel employing a 0 to 10 numeric pain rating scale where 0 and 10 indicate no pain and the worst pain, respectively.

Fluid control

Immediately following pulmonary resection, several conditions are known to enhance extravascular lung water (EVLW) expansion including fluid infusion in the intraoperative period. EVLW expansion can generate the impairment of gas exchanges that can lead to postoperative acute lung injury which is associated to mortality ranging from 20% up to 100% (21). Therefore, in our program, we suggest avoiding fluid overload, keeping fluid administration to a minimum and monitoring hydric balance with urinary drainage catheters positioned in the operating room.

Considering the critical role of the multidisciplinary team in patient engagement, we have developed and planned an educational program designed to train all ERAS members in order to enhance their professional ability to adopt the most effective measures in routine clinical practice. During this program of team education, different competences were shared and discussed, and a consensus on the best clinical practice was achieved.

Indeed, as previously reported (22), learning programs that teach nurses about patient engagement may be crucial to achieve positive impact on patient motivation.

The patient's booklet

To improve a patient's understanding of the various aspects of the protocol and to integrate along with the verbal instruction, we propose to provide the patient with written material, in the form of a booklet, illustrating all the care-plans that they are about to experience during the preoperative, intraoperative and postoperative period. The patients and family are asked to read well the booklet. Patients are asked to complete the checklist daily in order to monitor their progress and help them to control pain and improve performance. Patients feedback is requested at the end of the booklet to highlight features of the ERAS program that need improvement and verify the extent of involvement of the patients in decisions about their care.

The future: digital platform and applications for smartphones

In recent years, there has been a growing interest in digital platforms and applications for smartphones, containing specific information tailored to the patient. Indeed, the use of these technologies, the spread of tutorial videos and the prompt interaction between the different and numerous professional figures, may be much more effective than only the verbal or written information, allowing the patient to be much more compliant to the protocols.

Our project should be to create a digital platform where the information described in this article is made available.

Thus, considering that the correct understanding of the several protocols and care-plans, and that full adherence to them by the patient is crucial, we think that the use of tutorial audiovisual material, pictures and other multimedia format materials may be a valid option to make the patient an active participant of his recovery and be of benefit to him by positively impacting the outcome of his surgery and treatment.

Furthermore, the use of a mobile application, in addition to the previous information, may help the patient to continue keeping in touch with the different professional figures even in the postoperative period.

Conclusions

Discussion and sharing of operative protocols and goals among the Italian Thoracic Surgery Units accredited in the VATS Group has been crucial for identifying the ideal ERAS program to apply in our clinical practice.

Preoperative patient counselling, performed using verbal, written or multimedia materials, is essential to achieving the goal of the ERAS project: making the patient the main

character of his recovery, able to impact himself in the surgical and healing process.

A multidisciplinary team composed of a surgeon, anesthesiologist, dedicated nurse practitioner and physiotherapist, is required to give the patient a complete understanding of each aspect of his disease process and hospital stay.

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Footnote

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Patient Health Engagement (PHE) model in enhanced recovery after surgery (ERAS): monitoring patients' engagement and psychological resilience in minimally invasive thoracic surgery

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Abstract: In the last decade, the humanization of medicine has contributed to an important shift in medical paradigms (from a doctor-centered to a patient-centered approach to care). This paradigm shift promoted a greater acknowledgement of patient engagement as a crucial asset for healthcare due to its benefits on both clinical outcomes and healthcare sustainability. Particularly, patient engagement should be considered a vital parameter for the healthcare system as well as it is a marker of the patients' ability to be resilient to the illness experience and thus to be an effective manager of his/her own health after the diagnosis. For this reason, measuring and promoting patient engagement both in chronic and acute care is today a priority for healthcare systems all over the world. In this contribution, the authors propose the Patient Health Engagement (PHE) model and the PHE scale as scientific and reliable tools to orient clinical actions and organizational strategies based on the patient engagement score. Particularly, this work discusses the implication of the adoption of these scientific tools in the enhanced recovery after surgery (ERAS) experience and their potentialities for healthcare professionals working in thoracic surgery settings.

Keywords: Patient engagement; Patient Health Engagement model (PHE model); Patient Health Engagement scale (PHE-s); patient-doctor relationship; resilience

Citizens' expectations towards the healthcare system are changing in both quantitative and qualitative terms (1,2). Life expectancy has increased, thanks to continuous technical and medical advancements. Diseases once lethal and deeply impacting on patient's quality of life became curable or, at least, treatable. These issues translate into an increased demand for care and cure services, often over a longer period. Furthermore, thanks to the diffusion of new means of communication (with particular reference to the Internet) we assist to a more equitable access to health information sources (3,4): this contributes to enhance people knowledge about their health condition and the available options for its treatment and their willingness to be engaged in choices related to their health course. Today people know more about their health but ask to know even more: the phenomenon of expert patient is an example of this increasing desire to acquire health information in an effective way (5). Moreover, they expect to be updated about the continuous advances of medical research. As a consequence, patients today claim for an enhanced participation along their healthcare journey, in terms of ability not only to express their health priorities, but also to advocate for a better alignment of the healthcare system to their psychological experience and needs (6).

In the last decade, the humanization movement in medicine has contributed to an important shift in medical paradigms (7,8). From an exclusive focus on the organic components of the disease (i.e., "doctor-centered model of care") medicine opened to a broader consideration of also the psychosocial components of the illness experience lived by the patient (i.e., "patient-centered model of care") (9). This paradigm shift promoted a greater acknowledgement of the potential impact of the patients' lifestyles and attitudes on their therapeutic adherence and thus on the clinical effectiveness of the medical intervention (10). The active role of the patient in his/her healthcare management became more and more a crucial focus for healthcare providers and a goal for therapeutic education (11). Therefore, we are assisting to an enhanced commitment of the healthcare system in sustaining patients and their family health literacy and in equipping them of the needed skills for effective self-management (12,13). The idea is that providing information to patients and increasing their literacy and self-management skills would improve patients' motivation to be more active and participative in the medical encounter and in the care process.

Several studies, to date, have demonstrated how the increased participation of patients in their healthcare is an important factor affecting medical adherence (14-16) patients' satisfaction about their healthcare experience and patients' psychological wellbeing (17-20). Furthermore, studies demonstrated how the enhanced participation of patients in their healthcare improves the quality of medical relationship, also contributing to reduce medical errors and improve safety of medical action (6,21,22).

Along this direction, there is increased acknowledgment about the importance of including patients' values and preferences in a shared decision-making process about treatments options. Behind this assumption there is the idea that the medical treatment will be higher effective if aligned with the patients' subjective priorities in terms of values and of quality of life expectations. This implies a change in the dynamics and philosophy of the medical encounter, towards a more open and reciprocal relationship: this means to recognize that both practitioners and patients are experts (the first one of the technical aspects of the care process and the second one of the subjective impact that the disease has on their life and of the criteria that lead them in positively or negatively evaluating their care experience) called to share their knowledge and experience in order to make the care process really aligned with the patients priorities and expectations (23-26).

However, medical information can be unfamiliar, difficult to be decoded and emotionally overwhelming for patients, particularly when they are experiencing critical moments in their healthcare pathway (such as the diagnosis moment, the occurrence of relapse, the decision to undergo a surgery…).

Critical health conditions, such as those typically linked to thoracic surgery, deeply impact on patients' emotional wellbeing and on their resilience ability (27,28). The diagnosis often is lived like a "bolt from the blue", even more critical at the psychological level when it is followed by the proposal to undergo a surgery. Furthermore, often in the case of thoracic surgery, patients come to the diagnosis without a real awareness of the gravity of their health condition due to the little visibility of signs and symptoms of the disease. Time after the diagnosis goes fast from patients' perspective. Patients describe the time after the diagnosis as an overwhelming sequence of duties and of emotionally burdening choices that they have to take in relation to their disease treatment. Patients and their families try to cope at their best with these various duties, although very often they feel not adequately equipped at the informative and emotional level. The option of a thoracic surgery is one of the most difficult and emotionally burdening among those requirements (29-31).

Given the specificities of thoracic surgery patients' psychological experience, it is key to guarantee the full alignment of the therapeutic team (and the whole healthcare organization) to patients and family psychological needs and expectations. Patients awareness and conscious participation to the decisions on treatment procedures is fundamental, not only in order to guarantee their informed consent, but to provide a protected and scaffolding relational space where patients and healthcare professional may feel real partners of a common health endeavor. In other term, to sustain patients' engagement in shared decision making and in the care relationship is a crucial predictor of the quality of patients' psychological and medical experience (32-36).

The concept of engagement is established in the scope of long-term treatment of chronic patients, particularly where integrated care models are concerned. Less attention has been paid so far to the application of patient engagement measures in the hospital setting and in particular in acute care. Experience of patient's engagement assessment and promotion in the specific setting of surgery, moreover, are just a few (15,37,38). However, given the previous premises, the setting of surgery appears particularly relevant and challenging for the promotion of patient engagement. At the organizational level, the hospital is the setting that often

corresponds with the first enrollment of a patient in the healthcare pathway. This first moment is crucial in order to set the base for the effective education of the patient and his/her family and for the construction of a good partnership not only with the doctor and the healthcare professional team, but also with the whole healthcare system. In this phase, specific actions need to be planned in order to foster patients' and family literacy about disease and treatment but also to sustain a process of psychological resilience to effectively face the post-acute care process. This is indeed a necessary condition to make patient engagement in healthcare a reality.

In other words, surgeons and their team are required to deal with the need of engaging their patients from the very beginning of their care relationship. This is the priority condition to guarantee patients' ability to engage also after discharge and in the follow up phases of their care pathway.

To focus of early patient engagement is particularly crucial in the scenario of new organizational models of patients' management in thoracic surgery such as enhanced recovery after surgery (ERAS) (39,40): this approach is finalized to improve the post-surgical period with a faster and more effective clinical recovery and the reduction of hospitalization.

Minimally invasive thoracic surgery is a cornerstone of ERAS: many review and different meta-analysis in the past years has demonstrate the improvement in surgical outcome in terms of duration of hospitalization, reduction of complication and pain both in the comparison of video-assisted thoracoscopic surgery (VATS) surgery *vs.* open surgery (41).

The Italian VATS Group has developed a project called "ERAS and Fast Track in VATS Lobectomy" that incorporates the individual aspects of this work, with the aim of obtaining an ERAS protocol for thoracic surgery that is complete, easily to apply, and fit for today's healthcare environment. The Italian VATS Group has a fundamental enrolment tool, the VATS Registry, in which all VATS lobectomies carried out by accredited Italian centers are recorded; to date, more than 5,000 cases have been included. In addition to this and for the purpose of the aforementioned ERAS project, a dedicated and prospective ERAS Registry was created to validate specific ERAS indicators for minimally invasive thoracic surgery.

The ERAS model drives to consider patients like co-protagonist of their care journey and crucial allied of the healthcare professional team to gain effective clinical outcomes. The engagement of patients, indeed, is a key factor to sustain the effectiveness of the clinical act and to guarantee patients adherence to therapeutic and life-styles prescription in the follow-up. However, the ability of patients to become co-protagonists of their clinical course is function of dedicated initiatives to inform and educate them. Furthermore, it depends on the quality of patient-doctor relationship: to be engaged, patients need a healthcare team able to recognize their illness experience in terms of emotional burden, willingness to be active participants in the healthcare process and oriented to motivate and reassure them.

In other words, surgeons as well as all the professionals involved in the surgical team, need to be sensitized and trained to an actual cultural change in thoracic surgery approach to the patients' care, finalized to a more aware promotion of patient engagement along the whole care pathway.

Monitoring and mirroring patient engagement: a goal of ERAS

If patient engagement in ERAS becomes a goal, it is important to equip healthcare systems and professionals with scientific measures to evaluate, monitor and promote the levels of patient's participation in their care.

The recently concluded Consensus Conference for Patient Engagement (42) advocated for a more systematic approach in patient engagement assessment within the healthcare system. The adoption of scientific measures of patient engagement, thus, is important according to different considerations. First, in a scenario of value-based healthcare, to insure strategies for giving voice to patients' and their caregivers about their needs and priorities is crucial (43). This may allow clinicians to best orient communicative and educational initiatives to the specific expectations of their patients (44). Systematically measure patient engagement levels, furthermore, may help clinicians become better empathetic to patients' experiences and psychological burden related to the disease and its treatment. However, this should be achieved with the support of scientifically validates measures, and should not only relay on the clinicians' subjective evaluation based on their professional experience. Furthermore, the adoption of validated measurement to assess patient engagement is a way to insure the best personalization of educational initiatives and relational acts. These interventions should be personalized according to the specific position of the patients along their engagement journey (8,36,45). Not all

patients, and not in all stage of their healthcare experience, indeed, are able and willing to really assume a proactive position in their healthcare management. A democratic and ethical perspective about patient engagement promotion, particularly in the ERAS setting, should move from this awareness in order to be maximally respectful of patients' values and priorities. Finally, the adoption of reliable measures for patient engagement in ERAS would allow to evaluate the effectiveness of educational initiative in promoting patients' participation, by providing useful feedback to optimize them and to guarantee their effectiveness and sustainability in time.

The Patient Health Engagement (PHE) model: mirroring patients' engagement and psychological recovery

The debate about patient engagement and about the importance of assess the level of patients' participation along their healthcare journey is florid and increasing year-by-year. Several tentative exist in the scientific literature to define engagement and its process of development. Among the most established definition of engagement, Légaré and colleagues (46) describe engagement as related to the patients' level of knowledge and literacy about their health status and their medical prescriptions. Their definition, thus, mainly consider the cognitive and informative dimensions of the engagement experience. According to these authors, the essence of engagement consists in the patients' ability to search for health information, to decode such information and to use them. Gruman and colleagues (47), mainly focused on the behavioural components of patient engagement and on the level of patients' ability enact effective self-care behaviours. These behavioural indicators are considered by these authors such an indicator of patients' ability to self-determinate their health status, and thus, of them being well engaged in their care. Hibbard and colleagues (48) developed the patient activation theory (and its related measurement PAM-13) and they underlined that the level of patient engagement depends on the level of patients' perception of self-efficacy and on their confidence on their own knowledge and ability to participate in the care process. These definitions, although substantial, do not capture and describe the emotional and psychodynamic component of the engagement experience, although scholars agree on the role of patients' emotional and psychological resilience in hindering or sustaining patients' participation in

healthcare (8,11,27,49,50).

This appears as a potential limit when patient engagement has to be applied in the setting of critical or acute care. As mentioned above, critical health conditions, the ERAS environment and the long recovery from surgery present unique challenges for patient engagement. Patients' participation in shared decision making and in the crucial points of treatment may be particularly burdensome for patients and their caregiver due to the acute psychological stress and the risk of death. Recently, some scholars emphasize that, at the contrary from chronic care management, in acute and in post-intensive care the physiological outcomes of the intervention may depend on the levels of patient and family engagement, such as function of patients' psychological resilience and sense of ownership of recovery (51). They thus claim for a revision of definition of patient engagement currently adopted in chronic care management in order to highlight the role of emotions and of psychological resilience to the health condition in such a process.

The component of psychological resilience and of identity reconfiguration along the process of engagement is the key element of the PHE model developed by Graffigna and colleagues (52). This model of patient engagement, rooted in the tradition of health psychology, describes engagement as the result of a complex process of psychological adaptation to illness and to the impact of this on the patients' self-image. The possibility for a patient to assume a proactive and participative position in healthcare, indeed, is featured by this model as the result of a complex dynamics among cognitive, emotional and behavioral components of the illness experience. The evolution along this "journey of engagement" is function of the balanced activation of such experiential components and in particular of patients' ability to self-determinate as an "author" of his/her healthcare course and of requiring a sense of ownership on his/her disease trajectory and quality of life (20). This model has been developed on the basis of extensive qualitative and quantitative studies of illness stories across different disease conditions and age cohorts and showed applicability in a broad spectrum of acute and chronic settings.

The PHE model features four positions of patient engagement, as described below (see *Figure 1*).

Blackout

The occurrence of a critical episode (e.g., a new diagnosis, the worsening of a disease condition, a disease relapse,
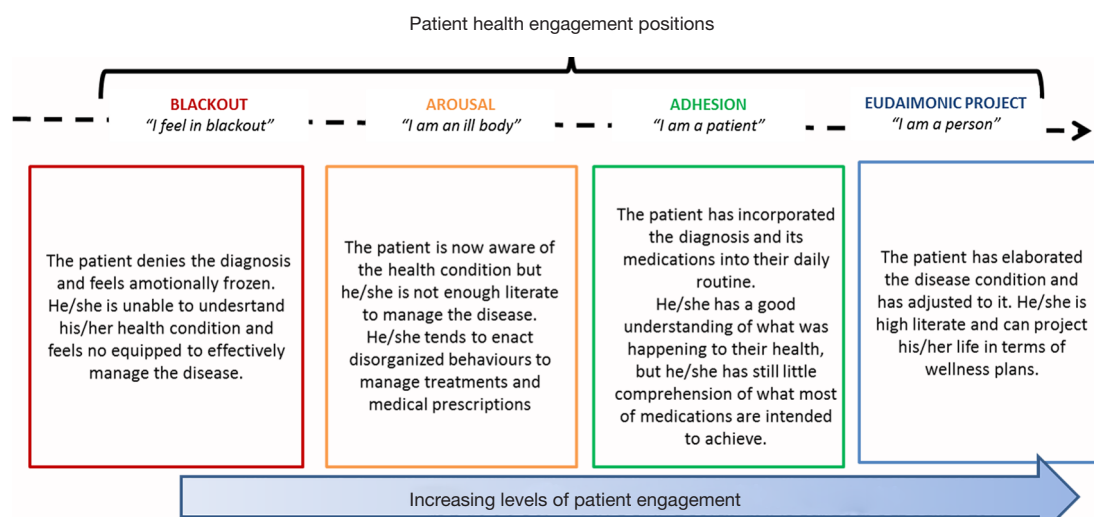
Figure 1 The PHE model. PHE, Patient Health Engagement.

etc.) leaves patients in a state of emotional, behavioral, and cognitive blindness. Patients in this position perceive a sense of lost control over the disease and their life. They feel "in suspension", and report state of anxiety. In this position of their engagement journey, the disease onset and its management are lived as overwhelming and unacceptable. At this stage, patients do not have yet acquired effective coping strategies to manage their new health condition, and they feel confuse about the changes occurring in their health status and in their body. Furthermore, patients in this position ten to have poor literacy about their health conditions, and they cannot easily elaborate the received information about their health condition (cognitive blindness). Moreover, patients feel blocked and unable to enable self-management actions (behavioral freezing). Patients in this stage, due to the disruptive emotive burden caused by the disease, appear completely focused on their illness, by scarifying other interests or activities. These patients are passive toward their healthcare system and they not engaged.

Arousal

In the position of "arousal", patients are hyper-attentive to every signal of their disease (emotional alert). Symptoms are lived as potential "alarms" that worries the patient and may cause acutely negative emotional reactions. Compared to the position of "blackout", in this position patients are better informed about their health condition, but their health literacy is still superficial and fragmented (superficial

knowledge). Moreover, they are not effective in enact self-management strategies (behavioral disorganization). These patients are at the very beginning of their engagement journey since there are starting to acquire a first awareness about their health and treatment requirements. However, they are not yet equipped to engage in an enhanced participation in their healthcare.

Adhesion

In a more advanced stage of their engagement journey, patients acquire a broader spectrum of health literacy (cognitive adhesion) and behavioral skills (formal adherence) to comply with medical prescriptions. They feel confident in their ability and motivation to cope with their illness. Furthermore, patients have accepted their health conditions and have elaborated the negative emotions connected with the critical health events showing a good resilience (acceptance). However, patients are still not autonomous in managing their health conditions and related treatment rules; they are not completely able to change their life style and to adhere correctly to the medication regimen, or at least they are not persistent in this. Every time life contexts change (e.g., going to holiday, travelling for work) or changes occur in their healthcare relationship (i.e. absence of the reference doctor, discontinuity of the healthcare team…) patients are challenged in their effort of being participative along their healthcare journey. Patients in this position experience an intermediate experience of engagement but they are still passively complying to the

healthcare systems requirements because they have not fully understood and elaborated the rationale behind medical prescriptions (e.g., the final "whys" of rules and treatments).

Eudaimonic project

In the "eudaimonic project" position, patients have fully accepted their condition; furthermore, they have understood and elaborated that the "identity of patient" is only one possible identity. They are able to better incorporate the disease into their life projects, and they are no longer overwhelmed (such as in the blackout phase) by their health conditions; rather, they are able to integrate other spheres of their lives (elaboration). In this position of engagement, they appear more self-determined and resilient at the psychological level. To achieve this emotional elaboration, they use internal resources to project satisfactory life plans for their futures. Patients gradually become co-producers of their health, and they are capable of enacting more effective health management. In this process, patients become more active in effectively search for information about their disease conditions and management. This allows them to better master their healthcare experience at the psychological level (sense making) and to enact self-management conducts more effectively, despite eventual changes in the context (situated practices). Patients mature a positive attitude towards their illness and its treatment, being aware that "they are not their disease" and that despite the diagnosis it is still possible to maintain some form of satisfactory quality of life.

Application of the PHE model in the clinical setting: the PHE scale (PHE-s)

The model has been operationalized into a scientific measure, which allows to easily evaluate the level of patient engagement along the medical journey: the PHE-s (53).

The PHE-s is a patient self-administrable short psychometric questionnaire developed with the aim of diagnosing the level of patient engagement in their healthcare process that is function of his/her degree of emotional elaboration of the health condition. The clinician has to explain to the patient the aim of the assessment by specifying that they should refer to how he/she is currently feels in relation to his/her health status to answer the questions. The response options featuring this instrument (i.e., ordinal scale) allow patients to easily mirroring their current emotional states within a continuum of possible emotional states and illness

experience. The PHE-s, indeed, allows to easily assessing the position of engagement of the patient by asking five simple questions. The PHE-s options of answer features the different possible experience of a patient along his/her process of psychological elaboration about the mutated health condition and of their engagement needs (way of "feeling" when reflecting on health status). This instrument is today the only one specifically dedicated to assess the degree of emotional elaboration and adjustment reached by the patient concerning his/her ability to engage in health management.

The specificity of this scale lays in the fact that it is rooted in a solid scientific framework of patient engagement. This allows not only to assess the actual patient's attitude towards his/her engagement and self-management, but also to detect patients at risk for disengagement and thus to design preventive targeted intervention to educate and motivate him/her to be more compliant and participative. Thus, the PHE-s engagement outcome is useful to orient clinicians, caregivers, policy makers and researchers in better personalize educational and counselling programs by making them better aligned to patients' priorities and expectations. Moreover, this tool allows clinicians to better understanding their patients' illness experience, and, consequently, this improve their communication and relational skills. *Figure 2* shows the instruction for the administration of the PHE-s. *Figure 3* shows the complete PHE-s.

The PHE model in practice: implication for medical practice

The PHE model and the PHE-s, as discussed in the previous paragraphs, might be concrete tools to collect a deep understanding of the patients' emotional status and of their ability to be active agents in their disease management. Furthermore, these instruments allow practitioners to have a dynamic picture of the patient engagement journey and to identify the position of engagement featuring a patient. This is particularly crucial if we consider that patient engagement is a process along which patient's needs, priorities and role expectations change basing on the phase occurring. As a consequence, to make a patient evolve from one phase to the subsequent one it is necessary to detect his/her priority needs and to effectively address them.

Research on the PHE model widely discussed the phase-specific levers to sustain the evolution of the patient engagement trajectory.

Following, you will find 5 statements that describe how a person might feel when thinking about his/her disease. Each sentence can be completed by indicating one of the 4 states or the intermediate points between two states. Please, indicate the state that better describes you by indicating the corresponding position.

Following an example to help you in answering the questions

Example 1
When I think about my health status…

| I feel sad | | I feel anxious | | I feel resigned | | I feel relaxed |

●　　○　　○　　○　　○　　○　　○

if you were sad when thinking about you disease, you would indicate the first position

Example 2
When I think about my health status…

| I feel sad | | I feel anxious | | I feel resigned | | I feel relaxed |

○　　●　　○　　○　　○　　○　　○

if you were in an intermediate position between sadness and anxiety when thinking about you disease, you would indicate the second position

Figure 2 Introductive formula to propose the PHE scale to the patient. PHE, Patient Health Engagement.

Thinking about my health status…

1	I feel psychologically frozen and blocked	I feel alert	I am aware	I feel positive
	O　O　O　O	O　O	O	O
2	I feel dazed	I feel worried	I am conscious	I feel peaceful
	O　O　O　O	O　O	O	O
3	When I think about my illness, I feel overwhelmed by emotions	I feel anxious every time a new symptom arises	I am used to my illness	Despite my illness, my life does not change much. OR I find my life meaningful despite my illness
	O　O　O　O	O　O	O	O
4	I feel very discouraged due to my illness	I feel anxious when I try to manage my illness	I have adjusted to my illness	I feel optimistic about my future
	O　O　O　O	O　O	O	O
5	I feel totally oppressed by my illness	I feel upset when a new symptom arises	I have accepted my illness	I have a sense of purpose despite my illness
	O　O　O　O	O　O	O	O

Figure 3 The PHE scale. PHE, Patient Health Engagement.

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Particularly, to pass from the blackout position to the arousal position the patient should be emotionally sustained and supported in being resilient when facing his/her new health condition. This also means to help patients in overcoming the emotional confusion emerged after the diagnosis, by building a trusted relationship with the healthcare provider. The health practitioner is asked, particularly, to scaffold patients and offer solidarity by making an empathic response and educating patients about the nature and the characteristics of their new health condition. This informative action is expected from the referential clinician who becomes, since the time of the diagnosis, the main interlocutor for the patient along the care process. If patients fail to build a reliable and trusted relationship with the healthcare provider, their emotional responses may become dysfunctional, often leading to the patients' dropout. In this phase, technologies that facilitate the communication with the referential clinicians and the monitoring of symptoms—such as telemonitoring or wearable devices—can make the patient feel protected and safe.

To pass from the arousal position to the adhesion position the patient need to become confident and feel effective in managing his/her health condition. Patients in this position need to be motivated and sustained in an effective behavioral change regarding their care and life style. In the arousal position, indeed, patients perceive healthcare professionals as an important point of reference who can help them managing their illnesses and treatment experiences which are a cause of stress. This requires clinicians to set realistic goals and positively reinforce patients when they succeed in managing the disease and the treatments. To foster a good relationship with healthcare providers since the time of diagnosis allows patients to improve their confidence and self-esteem. Healthcare professional, beside motivating patients to self-management behaviors, should also legitimize their active role and their willingness to become protagonist of their care. Technologies in this phase could be useful to generate in the patient a sense of mastery over their illness experience and to network with other individuals in similar conditions in order to share practices and solutions to face with the disease.

To pass from the adhesion position to the eudaimonic project position, the patient should acquire a more positive approach to their illness and their life, becoming more optimistic to their ability to improve quality of life. Their resilience in the disease journey need to be sustained and they should be motivated and educated in broadening their perception horizons, in terms of not being exclusively focused on the disease and its treatment, but also inclusive of other life sphere which may be potential source of motivation and optimism. Health coaching and positive psychological intervention may be important in order to allow the patients to adjust from the traumatic health experience and to lessen the negative impact of the disease on quality of life. To achieve this goal, it is important to sustain patients in maintaining active social roles in their communities and satisfactory interpersonal relationships. Furthermore, patients need help to make realistic plans and to set achievable goals in their quality of life management. In other words, patients need to be sustained in re-achieving some form of life projects, even if confined. Patients in the eudaimonic project position, furthermore, need to be sustained in their motivation and ability to influence other patients towards a more engaged approach to their healthcare. These patients may become privileged testimony of a positive and effective approach to illness and healthcare and they may lead the process of engagement transformation of their peers. In this direction, the role of patient association and patient advocacy is crucial and need to be sustained. Patient association may become the testing ground (and the magnifier) of good practices of patient engagement. At this stage new technologies may play an important role, not only with self-monitoring tools, but also allowing patients sharing and networks, patient advocacy and the storytelling of illness (and healing) experiences that may motivate and support at the emotional level patients still at the beginning of their engagement journey.

The PHE model in the ERAS setting: the experience of the VATS Group register

To substantially contribute to the debate about patient engagement promotion in thoracic surgery, the VATS Group dedicated to the diffusion and improvement of the ERAS approach in minimally invasive, is experimenting the collection of patient engagement data within their patients' register.

As anticipated, the assessment of engagement levels and the monitoring of how these levels change in time is a first important goal to allow clinicians to better make patients active partners in their thoracic surgery experience. In particular, the introduction of PHE-s in the VATS register,

and the collection of patient engagement data along the healthcare journey will have both scientific and pragmatic relevance.

At the scientific level, this will allow to obtain "real words" data about the variance and evolution of engagement trajectories over time. Furthermore, since the clinical and socio-demographic data collected in the register are various and numerous, this would open to the possibility to study the co-variance of engagement and other clinical characteristics of the patients. Moreover, this will guarantee the possibility to perform secondary analysis aimed at modeling how the clinical, contextual and psychological variables interlace and influences each-others in the process of engagement. This real-world modeling of the causal relationship among key variables will produce a scientific algorithm able to understand what are the key factors (or levers) on which it is opportune to work in order to improve the levels of patient engagement

Further then at the scientific and theoretical level, it is evident how this experimentation, if successful, may impact on clinical practice. The objective of the PHE-s is, indeed, to equip the healthcare professional with an easy and applicable measure to scientifically assess the levels of engagement. This, thanks to the linkage between the scale outcome and the PHE model, may provide the clinical team with concrete cues on patients' experience and with advices and strategies to intervene at the best.

Conclusions

Although the debate about the clinical and organizational value of patients' engagement is already well established in the scope of chronic disease management, less experience has been matured in the setting of acute care, and in particular in surgery.

However today the diffusion of new approach to surgery, such as ERAS or Fast Track put into question the need for a deep revision of traditional medical paradigms. The success of an ERAS approach in surgery, indeed, is not only dependent on the innovation of technological supports and of therapeutic acts. It is also dependent on the ability of the healthcare system and the surgery team of engaging patients in become more participative in their treatment and illness experience.

Particularly thoracic surgery is often lived by patients as a burdensome experience. The diagnosis and the consequent request of undergoing a thoracic surgery is often unexpected for patients and their families. This usually generates discomfort and negative psychological responses. In order to become able to cope with the disease and the stress of the therapeutic action, patients need to be sustained in their emotional journey of acceptance and resilience. Furthermore, the ability of patients to cope with their emotions and to assume a more positive approach to their illness and its treatment is a key to sustain patient engagement along the healthcare pathway.

Moving from these premises, in this article we have argued how the PHE model, which features the evolution of patient engagement trajectories and of its implication at the psychological level, may be a useful framework in thoracic surgery, particularly when the ERAS approach is concerned. This process-like modeling of patients' engagement potentially leads to a real revolution of healthcare paradigms in research and intervention by posing the bases for a true and sustainable partnership between patients and health practitioners. In this perspective, while the process of patient engagement evolves, even the patient-practitioner relationship assumes different shapes (from passivity to partnership) thus implying a continuous realignment of roles and power dynamics.

The PHE model, operationalized in the PHE-s, allow clinicians to easily assessing patients' level of engagement, and thus their needs and expectations in terms of doctor-patient communication, health literacy and therapeutic education. The introduction of the PHE-s along the patient journey, thus, would allow to track the evolution of patient engagement, to identify critical cases and even to verify the effectiveness of patients support programs in sustaining patients' psychological resilience and participation in healthcare.

PHE-s has been inserted in the Italian VATS Group and ERAS Registry. This testifies an important turning point in the cultural approach to patients' role in thoracic surgery. This experimentation deserves particular attention due to its scientific and clinical potential. It would allow—for the first time—to collect real world data about patient engagement trajectories in ERAS surgery and to put this in relationship with clinical and socio-demographic data of the patients.

A very ambitious project that at least it is worthy to be pursued. Future results will tell if the experimentation has been successful and fruitful.

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Footnote

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Enhanced recovery pathways in thoracic surgery from Italian VATS group: nursing care program

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Abstract: Enhanced recovery after surgery (ERAS) is an interprofessional program that can lead to hastened patient recovery and reduced time in hospital. Nursing staff play a key role in the implementation of enhanced recovery protocols. This issue focalizes the role of nurses in ERAS program for patients submitted to Thoracic Surgery, in particular for cases of major lung resection performed by a minimally invasive surgical approach (VATS, video assisted thoracic surgery).

Keywords: Enhanced recovery after surgery (ERAS); video assisted thoracic surgery (VATS); video assisted thoracic surgery lobectomy (VATS lobectomy); lung cancer; nursing plan

Introduction

The Italian video assisted thoracic surgery (VATS) group has developed a project called "Enhanced recovery after surgery (ERAS) and Fast Track in VATS Lobectomy" that incorporates the individual aspects of this work, with the aim of obtaining an ERAS protocol for thoracic surgery that is complete, easily to apply, and fit for today's healthcare environment.

ERAS is an interprofessional, goal-directed program that begins in the preoperative period and extends through hospital discharge. The aim is to decrease perioperative stress, improve pain management and mobilization and minimize post-operative complications. This can lead to hastened patient recovery and reduced time in hospital. ERAS approach is multidisciplinary and requires the coordination of surgeons, nurses, anaesthesiologists, physiotherapists, dietitians (1). Programs typically include components such as patient assessment, exercise training, education, nutritional intervention, and psychosocial support.

This issue focalizes the role of nurses in ERAS program for patients submitted to Thoracic Surgery, in particular for cases of major lung resection. Although ERAS principles can be applied to open surgery too, they better fit to patients treated by a minimally invasive surgical approach (VATS).

The Italian VATS Group has a Registry, in which all VATS lobectomies carried out by accredited Italian centers are recorded; in addition to this and for the purpose of the aforementioned ERAS project, a dedicated and prospective ERAS Registry was created to validate specific ERAS indicators for minimally invasive thoracic surgery.

Herein ERAS nursing plan is described and a concrete work map is provided for nurses of Thoracic Surgery Units adhering to the project. The nursing staff is essential in each phase of the above mentioned project, as the nurse is the nearest figure to the patient. The closest contact with him is related to the time spent together, the number of meetings and telephone reports and the higher degree of confidence with him. The figure of the care provider is already, institutionally set; he/she is also called 'Thoracic

Surgical Nurse Specialist' (TSNS), like at St James's University Hospital, Leeds, UK (2).

The enhanced recovery pathway

Tables and checklists that the nursing staff should utilize for daily care and the indicators of the ERAS program implementation are included in the Supplementary.

Preadmission information, education and counseling

Patients should receive information in both written and oral form (digital supports like DVDs are useful, too). They should receive a diary that describes what they can expect to happen on each day after surgery. The diary has spaces for them to write down their progress and concerns.

Information provided by the nurse at the time of diagnosis are:

❖ Information on milestones of ERAS program.
❖ The principles of patient education: the nurse should ensure that patients and carers are aware of the importance of self-management in order to obtain a quicker recovery and to prevent postoperative complications.
❖ Information about the surgical procedure (fears about surgery are indications to call further meetings with the surgeon).
❖ The functioning and managing of chest drains.
❖ Information about anaesthesia and post-operative pain (emerging fears about this topic lead to request further interviews with anaesthesiologists). A detailed presentation is given with a particular focus on the reasons why pain control is required, how this is delivered and the potential side effects of medication. Sjöling *et al.* (3) reported that patient satisfaction with pain management is significantly correlated to the preoperative information received.
❖ Explanations on discharge criteria.
❖ Discharge advice, with regards to wound management, pain control, physiotherapy, driving and flying. Often questions are asked by patients and carers, about what type of care is required after surgery and if any additional help will be required at home.

Preadmission optimization

Patients should be prepared to the surgical treatment, both psychologically and physically, as for a sports competition. They should arrive at surgery while being at their physical optimum. Prehabilitation, defined as enhancement of the preoperative condition of a patient, has been proposed in order to augment functional (exercise) capacity before the surgical procedure, thus minimizing the postoperative morbidity and accelerating postsurgical recovery. The following items have to be tested, assessed and optimized by counseling or other actions, previous to surgery: smoking (if yes, counseling for cessation), alcohol (if yes, counseling for cessation), hyperglycemia (if yes, control blood glucose at a reasonable level), anemia (if yes, administer iron therapy, erythropoiesis-stimulating agents), mobility, dyspnea.

As for mobility, patient handling assessment is aimed to state if the patient is able to walk, stand up, go in or out of chair, toilet, transfer, move in bed etc. and if he/she does that independently or with the aid of auxiliary devices or carers. Handling assessment includes a personalized, mobilization program, too. For the latest topic (dyspnea), a patient unable to walk 3 flights at the stair test should be rigorously referred to physiotherapists for a more intensive rehabilitation program.

The physiotherapist (or often the nurse) should deliver, in this phase, an educational session on physiotherapy which includes advice on exercise prior to admission, the days following surgery and what to do when at home. Incentive spirometry (I.S.) devices should be given for preoperative exercise. The patients and carers are invited to take active part in the exercises with the physiotherapist/nurse, demonstrating the correct application of each exercise.

Preoperative preparation

❖ Avoid mechanical bowel preparation (excepted for patients with absence of defecation for more than 3 days).
❖ Prescribe fasten from solids 6 h prior to anaesthesia.
❖ Invite the patient to drink clear liquids (4,5) until 2 h before anaesthesia: it has been demonstrated to improve wellbeing.

Examples of clear liquids include, but are not limited to, water, fruit juice without pulp, carbonated beverages, carbohydrate–rich nutritional drinks, clear tea, black coffee (4).

As for carbohydrate drinks (not suited for diabetics), the amount expected is 800 ml the evening before and 400 mL 2 h before surgery. They are described to reduce nausea and vomiting and attenuate the increase in insulin resistance related to surgery (6).

❖ Administer LMW heparin 12 h before surgery.
❖ Avoid premedication (this is to reserve only to patients who refer at the interview a significantly high degree of anxiety before surgery).

Intraoperative phase

It includes:
❖ Admission of the patient: the nurses invite the patient to walk to the operating theatre and they give to him/her all the support he/she needs; they make final blood tests, too.
❖ Administration of antibiotic prophylaxis prior to incision, if scheduled by the centre.
❖ Skin preparation: it includes firstly a shower (with plain soap), then hair removal only if necessary (by hair clipping in the operating room, immediately prior to surgery) and lastly the use of a skin antiseptic solution (preferably chlorhexidine-alcohol solution) (7).
❖ Thoracic epidural analgesia/multimodal analgesic strategies, performed according to the anesthetist's guidelines
❖ Active warming (using air blanket and intravenous fluids warmer) in order to prevent intraoperative hypothermia. Hypothermia has been shown to impair drug metabolism, adversely affect coagulation, increase bleeding, cardiac morbidity and wound infection (8-10). Post-operative shivering also increases oxygen consumption and can worse pain (11).
❖ Post-operative nausea and vomiting (PONV) prophylaxis only in patients defined at high risk for PONV, according to a preoperative screening.
❖ Balanced intravenous fluids: intraoperative crystalloids 500–1,000 mL for surgery <3 h, otherwise crystalloids 1,500 mL, colloids 500–1,000 mL.

Postoperative care

❖ As for postoperative fluid management, administer crystalloids 500 mL during the first 24 h, then stop. With the commencement of oral diet and oral analgesia as soon as tolerated after surgery, post-operative intravenous fluids administration beyond 12–24 h is rarely needed. Indeed, intravenous fluids should be terminated within 24 h after surgery. In addition to a short duration of fluid therapy, enhanced recovery protocols reduce also the total volume of fluids (generally at about 500 mL). This

is because a zero balance fluid regimen is associated with fewer cardiopulmonary complications (12). Moreover, balanced crystalloid solutions are preferred to 0.9% normal saline, in order to reduce flux across the extracellular space.
❖ Remove epidural catheter after 48 h; then, administer oral analgesics (paracetamol, for example).
❖ Remove urinary catheter within 24 h.
❖ Avoid or remove, as soon as possible, patient monitoring devices: arterial catheter, electrocardiographic electrodes, bracelet to measure blood pressure, patches on previous skin needle punctures, other monitoring wires, oxygen mask (replaced by nasal cannula if really necessary). This enhances patients' early mobilization.
❖ Promote early feeding (defined as having oral intake of fluids or food within the first 24 h after surgery). It is generally recommended in all existing enhanced recovery programs. It begins with free fluids 4 h after surgery and hence, continue with normal diet from the day of surgery. Flavored high energy protein drinks are prescribed twice to three times a day. They are a useful 'bridge' to a normal diet, ensuring some protein and calorie intake early in the recovery process. However the existing evidences are weak, due to contrasting results, and further studies are needed.
❖ Promote early restart of the intestinal function. As for the prevention of ileus, laxatives are commonly used within enhanced recovery protocols, but no high quality data is available. Perioperative use of chewing gum (or alternatives, in edentulous patients) is shown to decrease ileus and length of stay (13).
❖ Promote mobilization within 24 h (in chair after about 4–6 h and walk at about 8–12 h, or in any case, as soon as tolerated).

For example:
❖ The patient will be helped to wear their garments soon, coming in the ward from the operating room.
❖ He will be early mobilized or placed sitting in a chair beside the hospital bed; the amplitude and frequency of the peripheral arterial pulse and the presence of perspiration will be detected. It may happen that during the first mobilization, the patient experiences fainting. In that case, the nurse will reassure and help him/her to go back to bed, and will try again later.
❖ At meal time, the patient will be invited to sit at the table.
❖ During the first mobilization, he will be invited to

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walk, short distances to get started, and afterwards greater distances, backed by health professionals or by a relative or by a walker (provided with oxygen, if necessary).

❖ By the first postoperative day (POD1), the 'out of bed' strategy should increase 6 h of duration per day, alternating sitting on chair with walking around. The patients will find on the diary the goals of mobilizations for each day and will write in what they have achieved. For its part, the nursing staff will ensure that the patients have the correct level of pain relief to make mobilization as comfortable as possible.

Ambulation and frequent position changes (first in bed and then out of bed) are central part of postoperative recovery programs, as they optimize ventilation and clear airway secretions; patient's mobilization is considered an interdisciplinary teamwork responsibility. There is evidence to suggest that increasing physical activity prior to surgery contributes to improve patient outcomes (14,15).

❖ Respiratory physiotherapy can improve postoperative dyspnea and health-related quality of life, with important psychosocial benefits. It comprises techniques that promote increasing lung volumes, as deep breathing exercises with or without devices (I.S.); other techniques focus on airway clearance, as coughing, postural drainage, percussion, vibration and shaking, if necessary. Furthermore, exercises for upper extremities and soft tissue release techniques are also used. The specific effects of respiratory physiotherapy after lung resection are the main topic of a recent protocol for systematic review (16) that will show the real importance of physiotherapy after lung resection. Probably, for Thoracic Surgery, this ERAS topic represents the most obvious difference from surgery of other body districts. It remains to be determined exactly which types of physiotherapy interventions are most effective. For example, as for I.S. in abdominal surgery, 2011 AARC guidelines (17) stated that "I.S. alone is not recommended for routine use in the preoperative and postoperative setting to prevent postoperative pulmonary complications…It is suggested that deep breathing exercises provide the same benefit as I.S…. Routine use of I.S. to prevent atelectasis in patients after upper-abdominal surgery is not recommended…".

❖ In ERAS program the nurse has the power to decide

the discharge of a patient with non-complicated outcome, on the basis of discharge criteria established by the surgeon in that center. These criteria may slightly vary according to center habits. Decision making for discharge is regulated by a protocol that takes into account air and fluid leaks in chest drains as well as clinical-radiological outcome. The above mentioned protocol chiefly depends on the type of pleural drainage used, water seal or digital, the latter being more objective, non-operator-dependent and therefore more prone to ERAS program. Generally the patient is discharged after removing the pleural drainage. In the event of prolonged air leaks, the surgeon will evaluate the possibility of leaving the patient out of the ERAS path or discharging him with the Heimlich valve. A provocative clamping could be useful, too. Obviously, at the moment of discharge, patients must have already received, by the nursing staff, whatever is necessary to complete their recovery at home.

❖ Follow-up is an important topic of ERAS nursing pathway, as it replaces the care given during conventional postoperative hospitalization. It has its own foundation in assistance by home carers or relatives, which should be identified in the preoperative phase, during preadmission counseling. The ERAS nurse should give the patients clear instructions about who to contact after discharge in case of any problem (possibly a 24-hour telephone helpline; if it is not practicable, there should be a local network involving also the general practitioner or other emergency services).

❖ For the first week, telephone follow up will be carried out by the nurse once daily: the patient will be interviewed about pain, dyspnea, pleural drainage if present, and will ask general questions about recovery ("I feel like this – is that right?"). If deemed necessary, the nurse will consult the surgeon to resolve some problems.

❖ Finally, a systematic audit, for example a bi-monthly meeting, is desirable, as staff need to evaluate the impact of what they do and should be encouraged to figure out how to best make ERAS fit their organization.

Conclusions

ERAS involves specific interventions at pre-operative,

perioperative and post-operative point of care.

Nursing staff play a key role in the implementation of enhanced recovery protocols and a successful execution of the new pathway is related to a strict collaboration with the other healthcare professionals.

ERAS program includes radical changes in the structured working day of nursing staff, but also gives a new approach to evidence based care. The new way to care aims to optimize outcomes and improve patient experiences.

This is the reason why nursing staff must believe in the importance of ERAS pathway; their ability to adapt the program and to suit the variable local contexts enables their success.

Nursing workload, as Hübner et al. demonstrated in their study (18), is decreased by systematic implementation of an enhanced recovery protocol and the increasing compliance with ERAS protocol significantly correlates to decreasing nursing workload.

ERAS development create a culture in which teams can function well, team members flourish and patients receives the best care.

This protocol is based on the best available evidence in literature. Recommendations were made on the basis of existing guidelines (7,18-22), borrowed from other surgical disciplines. The practice of this protocol will help to realize if it needs to be modified on the basis of cardiopulmonary implications and peculiarities of thoracic surgery.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Italian VATS group

Enhanced recovery programme - Nursing care map

WARD_____   CONSULTANT_____

PATIENT'S SERIAL NUMBER_____

AGE_____   SEX   M ☐   F ☐

PATIENT'S PHONE NUMBER_____

NEXT OF KIN_____(_____)   PHONE _____

GP NAME_____   PHONE_____

REASON FOR ADMISSION_____

PRE-ASSESS NURSE_____   DATE PRE-ASSESSMENT_____

DATE OF ADMISSION_____

DATE OF OPERATION_____

TYPE OF SURGERY (ACCESS)_____(_____)

DISCHARGE/TRANSFER: Expected date_____

Destination_____   Own transport avail.   YES ☐ NO☐

READMISSION DATE_____

Preadmission information, education and counseling

Topic	Yes/No	Indications/notes
Informations on ERAS programme		Milestones, discharge criteria and advice
Questions about surgery		If yes, refer to the surgeon
Fear about anaesthesia/pain		If yes, refer to the anaesthetist
Informations about chest drains		Functioning, Managing
PONV assessment: patient at risk?		If yes, plan systematic prophylaxis

Preadmission optimization

	Yes/No	Indications/notes	Yes/No
Smoking		If yes, counseling for cessation	
Alcohol		If yes, counseling for cessation	
Hyperglycemia		If yes, control blood glucose at a reasonable level	
Anemia		If yes, correction (iron therapy, erythropoiesis-stimulating agents)	
Mobility		(see PATIENT HANDLING ASSESSMENT and eventually make a nursing plan)	
Dyspnea: unable to walk 3 flights at the stair test?		If yes, ask the physiotherapists to start a more intensive rehabilitation program	

Patient handling assessment

Activity	Equipment (state)	Help of 2	Help of 1	No help needed
Walk				
Standing				
In/out chair				
Bed mobility				
Plan				

Date………………..   Signature……………………………..

Referrals

If significant respiratory or mobilization problems, refer to intensive physiotherapy				
If anxieties regarding patient condition at pre-assessment or pain, refer to anaesthetist				
If anxieties regarding surgery, refer to surgeon				
Referral to:	Date referred	Reason for referral/requirements on discharge	Date first seen	Name/contact no

Preoperative preparation

	Yes/No	Notes
Avoid mechanical bowel preparation		Excepted for patients with absence of defecation for more than 3 days
Fasten from solids 6 h prior to anaesthesia		
Clear liquids until 2 h prior to anaesthesia		
Carbohydrate drinks (800 mL the evening before, and 400 mL 2 h before surgery)		Not if diabetics
LMW heparin 12 h before		
Avoid premedication		Not if high degree of anxiety

Date………………..   Signature…………………………..

Decisions regarding care remain at the discretion of the clinician for patients who develop complications. Record clearly the reason for deviations from the plan.

Intraoperative phase

	Yes/No/not scheduled (NS)	Notes
Walk to the operating theatre		
Final blood tests		
Antibiotic prophylaxis		
Hair clipping		Only if considered necessary
Chlorhexidine-alcohol solution on skin		
Analgesics according to protocol		
Air blanket and/or intravenous fluids warmer		
PONV prophylaxis		In patients defined at high risk
Balanced intravenous fluids		Intraoperative crystalloids 500–1,000 mL if surgery <3 h, otherwise crystalloids 1,500 mL, colloids 500–1,000 mL

Date…………………   Signature………………………………………..

Postoperative care

	Yes/No	Notes
Crystalloids 500 mL during the first 24 h, then stop		
Remove epidural catheter after 48 h; then, oral analgesics		
Remove urinary catheter within 24 h		
Remove patient monitoring devices		
Early feeding: Free fluids 4 h after surgery Normal diet from the day of surgery		
High energy protein drinks		
Need for laxatives		
Mobilization (chair at 4–6 h, walk at 8–12 h)		
Physiotherapy		

Date…………………   Signature…………………………………..

Decisions regarding care remain at the discretion of the clinician for patients who develop complications. Record clearly the reason for deviations from the plan.

ERAS COMPREHENSIVE NURSING CHECKLIST   YES   NO or N/A

Understand enhanced recovery program and patients role   ☐

Written information provided   ☐

Discharge plans and criteria discussed   ☐

LMW heparin 12 h before   ☐   ☐

DAY OF SURGERY:

Preop drink given   ☐   ☐

Final blood tests done   ☐

Antibiotic prophylaxis given   ☐   ☐

Analgesics according to protocol   ☐

Intraoperative warming   ☐   ☐

Postop:

Drink fluids (4 h)   ☐   ☐

High energy protein drinks   ☐   ☐

Solid diet (8–12 h)   ☐   ☐

Sit on chair (up to 2 hours)   ☐   ☐

Walk   ☐   ☐

Incentive spirometry   ☐   ☐

Blood tests   ☐   ☐

Chest X-rays   ☐   ☐

Chest tube:	Air leaks	
	Fluids	
Pain:	NRS	
	Site	

Notes

_____

_____

_____

_____

_____

POD 1   **YES**   **NO or N/A**

Remove urinary catheter   ☐   ☐
(Monitor output for 12 h once removed)

Chewing gum   ☐   ☐
High energy protein drinks   ☐   ☐
Solid diet   ☐   ☐
Sit on chair   ☐   ☐
Walk   (>6 h/day)   ☐   ☐
Incentive spirometry   ☐   ☐

Chest tube:	Air leaks	
	Fluids	
Pain:	NRS	
	Site	

Notes

_____
_____
_____
_____
_____

POD 2

	YES	NO or N/A
Remove epidural catheter	☐	☐
Blood tests	☐	☐
Chest X-rays	☐	☐
Chewing gum	☐	☐
High energy protein drinks	☐	☐
Solid diet	☐	☐
Flatus passed*	☐	☐
Faeces passed*	☐	☐
*if not, laxatives given	☐	☐
Sit on chair	☐	☐
Walk (>6 h/day)	☐	☐
Incentive spirometry	☐	☐

Chest tube:	Air leaks	
	Fluids	
Pain:	NRS	
	Site	

	YES	NO or N/A
Ready for discharge	☐	☐

Notes

_____
_____
_____
_____
_____

Date……………… 　　　　　　　Signature………………………………….

Indicators of eras program implementation

1. Urinary catheter removal at 24 h
2. Commencement of solid, oral diet at 24 h
3. Mobilization in chair at 4–8 h
4. Deambulation at 12 h
5. Chest tube removal at 48–72 h
6. Pain control NRS <5
7. Control of dyspnea by physiotherapy
8. Discharge at 72 h or as soon as possible
9. Reduced readmission rate

Enhanced recovery pathways in thoracic surgery from Italian VATS Group: preoperative optimisation

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Abstract: Preoperative patient optimisation is a key point of enhanced recovery after thoracic surgery pathways. This could be particularly advantageous when considering video-assisted thoracic surgery (VATS) lobectomy, because reduced trauma related to minimally invasive techniques is one of the main factors favouring improved postoperative outcome. Main specific interventions for clinical optimisation before major lung resection include assessment and treatment of comorbidities, minimizing preoperative hospitalization, optimisation of pharmacological prophylaxis (antibiotic and thromboembolic) and minimizing preoperative fasting. Literature data and clinical evidences in this setting are reported and discussed.

Keywords: Video-assisted thoracic surgery (VATS); lobectomy; fast-track surgery

Introduction

Enhanced recovery after thoracic surgery protocols, in agreement with those proposed in other surgical disciplines, have been primarily developed to prevent factors of delayed postoperative recovery, and are established to achieve faster mobilization and resumption of regular activities with no increased or even decreased complication rate (1,2). Furthermore, reduction of perioperative complication rate is considered one of the primary goals to be reached to decrease length of hospital stay and related costs.

Interest in fast-track pathways can be further increased when considering video-assisted thoracic surgery (VATS) lobectomy, because reduced trauma related to minimally invasive techniques is one of the main factors favouring improved postoperative outcome (3,4).

Basic principles of these protocols promote a multidisciplinary approach since the first observation of the patient who is candidate to minimally invasive major lung resection, with the aim of optimising all the aspects of perioperative and intraoperative management on the basis of evidence-based best medical practice.

A large body of evidences has been published demonstrating that optimising clinical status of the patient before colorectal (5), breast (6), pancreatic (7), and urological (8) surgery may allow to reduce the physical and psychological stress related to the operation and to promote restoration of function. However, there is still paucity of similar reports in thoracic surgery, and specifically in lung cancer surgery, with no published data concerning enhanced recovery after surgery (ERAS) in VATS lobectomy.

A key point of ERAS protocols is that all patients who are going to receive elective surgery should undergo preoperative general assessment with the aim of establishing if they are fit for the planned operation. Especially in the case of patients with poor performance status, accurate preoperative evaluation should start as soon as possible after the initial diagnosis, and should include detailed patient history and clinical assessment, blood exams including basic metabolic panel and complete blood count, and

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measurements of pulmonary and cardiac function. It is very important to identify patient risk factors adequately in advance before surgery, to allow appropriate arrangements and interventions for possible preoperative optimisation.

Main specific interventions for clinical optimisation in the preoperative phase include:

❖ Assessment and treatment of comorbidities with special interest for those that can be modified within the interval of time between the first patient observation and the operation;
❖ Minimizing preoperative hospitalization;
❖ Optimisation of pharmacological prophylaxis (antibiotic and thromboembolic);
❖ Minimizing preoperative (as well as post-operative) fasting.

There are some other fundamental parts of preoperative optimisation such as physiotherapy and information of patients and their families, but these are not among the topics of this chapter and will be discussed elsewhere.

Patient optimisation for comorbidities and risk factors

Assessment of comorbidities and risk factors is a crucial point of patient evaluation in the preoperative phase. There is clear evidence in the literature that the presence of significant comorbidities increases the risk of post-operative complications, and that preoperative treatment of comorbidities and patient optimisation may contribute to significantly reduce complications after surgery. Unfortunately, there are many risk factors which cannot be modified with a specific treatment in a limited period of time, and therefore clinical intervention should be principally directed to those comorbidities that could be optimised during the interval between initial diagnosis and surgical treatment (generally few weeks).

Main pathologic conditions increasing the perioperative risk which can be treated and optimised whilst awaiting surgery include: anaemia, malnutrition, chronic obstructive pulmonary disease (COPD) and active smoking. These conditions will be discussed in the present chapter. Other frequent comorbidities such as diabetes and hypertension may only require optimisation of therapy for patients who have not adequate disease control, but the status of disease can hardly be modified before surgery. Additional conditions that significantly increase the surgical risk, such as obesity and alcohol abuse, have to be identified and considered when planning the operation, although they cannot be effectively treated in a short period of time before surgery.

Anaemia is defined as the deficiency of red cells in blood with hemoglobin concentration <13 g/dL in males or <12 g/dL in females. It is a common incidental finding in patients with cancer and therefore also in patients with lung cancer. There are evidences that the presence of anaemia increases perioperative morbidity and mortality of patients undergoing surgery (9). Therefore, it should be identified, investigated and treated before elective surgery. Blood transfusion is the most common method to improve hemoglobin levels in anaemic surgical patients. However, it can be associated with a higher risk of complications such as acute transfusion reactions, immunosuppression, post-operative infections that may be responsible of prolonged hospital stay (10). For this reason, in the preoperative setting, transfusion is usually reserved only to patients with severe anaemia (hemoglobin concentration <8 g/dL). Alternative strategies to treat minor degrees of anaemia include iron supplementation and erythropoietin, whose administration is associated with significantly lower complication rate and may contribute to reduce the need for transfusion. Although the beneficial effect of anaemia treatment in the perioperative period are well known, in the literature the utility of the latter therapeutic methods has been only assessed in the context of lung cancer patients undergoing adjuvant chemo- or radiotherapy (11), and there is still paucity of data in the surgical setting. In current clinical practice and in the context of ERAS pathways, preoperative treatment of anemia with iron supplementation or erythropoietin is generally recommended for all patients with haemoglobin level <10 g/dL.

Malnutrition is another relatively frequent condition in patients with cancer. The rate of patients with operable lung cancer showing a severe malnutritional status preoperatively has been reported up to 28% in some studies (12). This condition is associated with increased risk of impaired wound healing, immune dysfunction, muscle wasting with respiratory fatigue in the postoperative period. These problems result in delayed patient recovery and prolonged hospitalization. There is therefore a strong recommendation for screening malnutrition before surgery. Current guidelines also recommend (grade A evidence) that patients found with severe preoperative nutritional risk should receive nutritional support for at least 2 weeks before major surgery (13).

Definition of severe nutritional risk has been codified as the presence of at least 3 of the following conditions:

weight loss >10–15% within last 6 months, body mass index (BMI) <18.5 kg/m^2, Subjective Global Assessment Grade C, and serum albumin level <30 g/L with no coexisting hepatic or renal dysfunction.

In a French study enrolling almost 20,000 patients who underwent major lung resection in main national centres, the presence of a preoperative malnutritional status has shown a statistically significant impact on postoperative morbidity and mortality. In particular, there was a significant increase in operative death rate, surgical complication rate, respiratory complication rate and infectious complication rate in patients with preoperative BMI< 18.5 kg/m^2 [14].

To date there are still no definitive recommendations regarding the type of nutritional support to use before lung cancer surgery. Moreover, there is lack of data examining the impact of preoperative correction of poor nutritional status in lung cancer patients. Differently, some small prospective studies are available assessing the benefits of preoperative nutritional support in patients undergoing major resection for lung cancer with normal nutritional status.

A recent prospective randomized study has compared the postoperative outcome of 31 patients undergoing resection for non-small cell lung cancer (NSCLC) who received preoperative protein rich nutrition support (arginine, omega-3-fatty acids and nucleotides) for 10 days with the postoperative outcome of 27 patients receiving only normal diet. Thirty-five percent of patient in the experimental group and 40% in the control group were operated with VATS technique. This study showed that preoperative nutrition was beneficial in decreasing the complication rate (19% *vs.* 44%) and mean chest tube removal time (4 *vs.* 6 days) [15].

Another small prospective randomized trial has investigated the effect of micronutrient supplementation in postoperative outcome of patients with normal BMI who underwent lung cancer surgery [16]. In this study a combination of alpha-ketoglutaric acid and 5-hydroxymethylfurfural not only improved exercise capacity and reduced oxidative stress, but also resulted in a significant reduction in intensive care unit stay and postoperative hospitalization.

COPD is a frequent finding in patients undergoing lung cancer surgery, and is related with increased risk of postoperative pulmonary complications. There are several published studies showing that optimisation of the pharmacological therapy before surgery has a beneficial impact improving respiratory function and reducing the risk of pulmonary complications. In a prospective study including patients with untreated functional airway obstruction, those receiving a long acting bronchodilator treatment before surgery showed a significant improvement in preoperative global pulmonary function. Postoperative outcome was significantly better in major responders than in minor responders [17].

In another prospective randomized study analyzing patients with untreated COPD, the addition of inhaled steroid to long acting bronchodilator was related with improved preoperative FEV1 and decreased postoperative pulmonary complication rate [18] compared to long acting bronchodilator alone. There is also evidence that pharmacological optimisation associated with respiratory physiotherapy in the preoperative setting may result in significant functional improvement allowing the operation in patients previously considered unfit for surgical resection [19]. Based on current available data, optimisation of pharmacological therapy associated with respiratory physiotherapy should be recommended in functionally compromised patients with the aim of improving respiratory function and reducing perioperative morbidity.

Active smoking is generally reported as a significant risk factor for increased postoperative complication rate and mortality rate after major lung surgery [20]. There is also clear evidence in the literature that smoking cessation may reduce perioperative morbidity and mortality [20,21]. In a study from the Society of Thoracic Surgeons Database hospital mortality was 1.5% in patients who had smoked compared to 0.4% in patients who had not. Prevalence of major pulmonary complications was 6.2 % in current smokers and 2.5% in non-current smokers [21]. However, there are some published studies suggesting that smoking cessation immediately before NSCLC resection does not significantly impact postoperative pulmonary complication rate and therefore should not be the reason to delay surgical resection [22]. Moreover, in other studies there is no evidence of a paradoxical increase in pulmonary complications among patients who quit smoking within 2 months of undergoing surgery [23]. In general, benefits of smoking cessation are as higher as longer is the time of cessation before surgery. Musallam and colleagues report that smoking cessation at least 1 year before major surgery abolishes the increased risk of postoperative mortality and decreases the risk of arterial and respiratory events evident in current smokers [20].

Current guidelines for lung cancer patients' management recommend that smoking cessation should be always encouraged as soon as possible before surgery; however, the operation should not be postponed to allow this [23].

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Nicotine replacement and other therapies to help stop smoking are also recommended (24).

Preoperative hospitalization

There is evidence that prolonged hospitalization produces a negative psychologic impact on patient with potential effect on immune defence. Effective preoperative assessment, with identification and optimisation of main risk factors before hospitalization, has been proved able to reduce surgery delay or cancellation rate and increase patient satisfaction making prolonged preoperative hospitalization unnecessary. As a consequence, hospitalization before surgery can be significantly shortened, and same-day admission or admission the night before surgery for patients undergoing operation early in the morning can become the rule. This aspect, together with previous adequate detailed explanation of the intended perioperative pathway, also contributes to reduce patient anxiety with a favourable impact on postoperative outcome, thus decreasing the perioperative costs (2).

Antibiotic prophylaxis

Appropriate prophylactic antibiotic therapy has been shown to reduce infectious complication rate after thoracic surgery. No official guidelines exist for perioperative antibiotic use in noncardiac thoracic surgery. Despite some conflicting data and few randomized clinical trials, strong evidence exists supporting the use of perioperative antibiotic prophylaxis in pulmonary resection (25). Currently, no special indication has been provided in this setting for ERAS pathway and for VATS lobectomy, therefore general rules used in lung surgery can be used.

Since preoperative airway colonization with pathogens represents a significant risk factor for the occurrence of lung infections after thoracic surgery, special care must be taken when managing patients with COPD or abundant bronchial secretions. These patients may have received previous repeated antibiotic treatments with possible changes in usual pattern of flora and potential development of antibiotic resistance. The choice of prophylactic antibiotics is based on the most common pathogens likely to result in infections of the surgical site. In pulmonary surgery bacteria from normal skin and respiratory flora are the most common cause of infection. These include *Staphylococcus Aureus*, coagulase-negative staphylococci, *Streptococcus Pneumoniae* and gram-negative bacilli, with

S. Aureus being the most frequently identified pathogen (26). Main systematic reviews and randomized controlled trials show that first-generation cephalosporins, such as cefazolin, which provide adequate coverage for the most common pulmonary surgical site infections, are an appropriate choice for prophylactic antibiotic therapy. The appropriate dosage for cefazolin is 1–2 g I.V. prior to incision (27). Second-generation cephalosporins can be used as second choice. If the patient has history of methicillin-resistant *S. Aureus* or a penicillin allergy, then vancomycin 1 g I.V. can be used in place of cefazolin. Other alternative antibiotic to be used in case of allergy are macrolides (clindamycin).

According to the World Health Organization (WHO) Safer Surgery checklist (28) the preoperative administration of antibiotic should be performed 60 minutes or less before surgical incision. Ideal time is 30 minutes or less before the operation.

Thromboembolic prophylaxis

Based on observational studies, most patients undergoing lung cancer surgery should be considered at least at moderate risk for postoperative venous thromboembolism (VTE). In one study of 693 thoracotomies for lung cancer, symptomatic VTE was observed in 1.7% of patients despite routine use of pharmacological prophylaxis (29). In another analysis of 706 thoracic surgery patients, pulmonary embolism occurred in 7% of patients who did not receive prophylaxis, but there were no episodes of PE in patients receiving mechanical prophylaxis (29). VATS lobectomy is classified as a non-high bleeding risk operation. Therefore, since there are still no approved guidelines for VTE specifically in ERAS protocols, general guidelines for lung resection in patients with non-high bleeding risk should be used. American College of Chest Physicians (ACCP) guidelines for VTE prophylaxis recommend the following management:

❖ For patients with low risk for VTE: no prophylaxis or mechanical prophylaxis only (anti-embolism stockings, intermittent pneumatic compression devices or foot impulse devices);

❖ For patients with moderate VTE risk (Caprini score 3–4): pharmacological prophylaxis with low molecular weight heparin (LMWH) for 7–10 days or until discharge. Association of mechanical prophylaxis is optional;

❖ For patients with high VTE risk (Caprini score ≥5): pharmacological prophylaxis with LMWH associated

with mechanical prophylaxis (anti-embolic stockings or intermittent pneumatic compression devices) for 7–10 days or until discharge.

Preoperative fasting

Prolonged preoperative fasting may be responsible of metabolic and psychological stress. Fasting from the midnight before lung surgery has been a standardized rule in the past, and is still a persistent practice in many thoracic surgery units worldwide in order to reduce the risk of bronchial inhalation during anaesthesia and in the immediate postoperative period.

Currently there is a large body of literature data showing that shorter preoperative fasting is not related with increased perioperative complication rate. A systematic review appeared in 2003 led to conclusion that preoperative fasting period for clear fluids can be safely reduced to 2 hours without increased complication rate (30). Recent guidelines from the European Society of Anaesthesiology (31), based on a high level of clinical evidence, recommend that all patients undergoing lung cancer surgery without specific risk factors for inhalation should be encouraged to drink clear fluids (including water, pulp-free fruit juice, tea and coffee without milk) up to 2 hours before elective surgery. According to the large majority of the members of the guidelines, tea and coffee should be still considered clear fluid with milk added up to about one third of the total volume. Solid food should not be prohibited up to 6 hours before elective surgery. In general, a light meal with toasted bread and liquids can be allowed up to 6 hours preoperatively, while a regular meal including fried or fatty food can be allowed up to 8 hours before surgery (31). There is now a large body of data showing that abstaining from fluids for a prolonged period prior to surgery is detrimental for patients; it is therefore important to encourage patients to keep drinking up until 2 hours before surgery to reduce their discomfort and improve their well-being (32,33). A previous study has shown that gastric volume was not increased after a light breakfast of tea and buttered toast consumed 2–4 hours before elective surgery (34). There is also a high level of evidence (coming from some prospective randomized trials) showing that drinking carbohydrate-rich fluids before elective surgery improves subjective well-being, reduces thirst and hunger and reduces postoperative insulin resistance (35,36). The evidence for safety is derived from studies of products (predominantly maltodextrins) specifically developed for perioperative use. Therefore, preoperative oral intake of carbohydrates has to be considered beneficial and safe up to 2 hours before elective surgery.

Conclusions

There is evidence that preoperative optimisation of the patient before major surgery including lung cancer surgery may allow to significantly reduce postoperative complication rate. This should therefore consider a fundamental part of enhanced recovery after thoracic surgery pathways. In the era of minimally invasive surgery the application of such principles could provide increased advantage in the perioperative outcome of patients undergoing VATS lobectomy.

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Footnote

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Anesthesia and fast-track in video-assisted thoracic surgery (VATS): from evidence to practice

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Abstract: In thoracic surgery, the introduction of video-assisted thoracoscopic techniques has allowed the development of fast-track protocols, with shorter hospital lengths of stay and improved outcomes. The perioperative management needs to be optimized accordingly, with the goal of reducing postoperative complications and speeding recovery times. Premedication performed in the operative room should be wisely administered because often linked to late discharge from the post-anesthesia care unit (PACU). Inhalatory anesthesia, when possible, should be preferred based on protective effects on postoperative lung inflammation. Deep neuromuscular blockade should be pursued and carefully monitored, and an appropriate reversal administered before extubation. Management of one-lung ventilation (OLV) needs to be optimized to prevent not only intraoperative hypoxemia but also postoperative acute lung injury (ALI): protective ventilation strategies are therefore to be implemented. Locoregional techniques should be favored over intravenous analgesia: the thoracic epidural, the paravertebral block (PVB), the intercostal nerve block (ICNB), and the serratus anterior plane block (SAPB) are thoroughly reviewed and the most common dosages are reported. Fluid therapy needs to be administered critically, to avoid both overload and cardiovascular compromisation. All these practices are analyzed singularly with the aid of the most recent evidences aimed at the best patient care. Finally, a few notes on some of the latest trends in research are presented, such as non-intubated video-assisted thoracoscopic surgery (VATS) and intravenous lidocaine.

Keywords: Video-assisted thoracoscopic surgery (VATS); enhanced recovery after surgery (ERAS); anesthesia; mechanical ventilation; postoperative complications.

Introduction

Fast-track, or enhanced recovery after surgery (ERAS) is a concept of perioperative management that aims at shortening hospital stay in order to reduce patient morbidity and costs. It combines sophisticated, minimally invasive surgical techniques, preoperative patient optimization, and evidence-based clinical measures that minimize complications and fasten recovery. It was first introduced 20 years ago for colorectal surgery but has since been successfully applied to many other fields (hepatobiliary, vascular, urologic). The introduction of the video-assisted thoracoscopic surgery (VATS) has allowed development of such programmes in the thoracic setting. This has recently been linked to decreased in-hospital mortality (1).

Today, patients admitted for lobectomy are often discharged at home on the third postoperative day. To guarantee these results, many aspects of the perioperative

management have been revised. Some of these, like preoperative carbohydrate loading, are often managed by surgeons and have been analyzed in other publications. Others, like prevention of postoperative nausea and vomiting (PONV) or intraoperative hypothermia, are shared with other surgical specialties and will not be discussed here. The ones that are unique to anesthesia in thoracic surgery will instead be reviewed in the following pages, according to the most recent scientific evidences and to our regular practice. This article will specifically focus on the goals of fast-track surgery, i.e., (I) reducing postoperative complications and (II) speeding recovery times.

Preoperative period

Careful preoperative risk assessment and optimization of home therapy are mandatory before lung surgery (2). These issues are out of the scope of this manuscript, but it is important to underline the necessity to elaborate a tailored strategy comprising both the intraoperative and postoperative anesthetic care ranging from premedication to analgesic therapy.

Premedication

Preoperative anxiety is fairly common and has a dramatic impact on the patient's personal experience. Furthermore, evidence suggests a correlation with postoperative pain (3). Patient-doctor communication is paramount and should be actively pursued, with a special focus on the clinical path undertaken. Analgesics and sedatives can be prescribed during the preoperative evaluation.

In the operative room, anxiolytics or opioids are often administered to increase patient's comfort while procedures such as vein cannulation or regional anesthesia are performed (4). Controversy arises in the choice of agents to be used, especially when focusing on ERAS goals. Long-acting drugs need to be avoided as they defer postoperative recovery (5). They have been linked to psychomotor disability, reduced mobilization, and late refeeding. Inability to take fluids or food per os is related to delays in full recovery (4). Short-acting drugs such as midazolam are therefore usually preferred. Despite its short-acting profile, even midazolam has shown residual effects during longer evaluation time frames (6), and clinically, it has been associated to late discharge from the post-anesthesia care unit (PACU) (7) and lower scores on psychomotor

performance tests (8). Its routine use should be avoided, especially in the elderly (9), and reserved for selected cases. Protocols aimed at reducing the duration of post-anesthesia care are already implementing this idea (10). In general, all benzodiazepines should be withheld.

Intraoperative period

Management of general anesthesia

Intraoperative pharmacologic management should be tailored to the goals of fast-track surgery, i.e., rapid recovery times and minimal side effects. Both inhalatory agents and total intravenous anesthesia have been successfully used for thoracic surgery. In order to minimize PONV (11), propofol [induction: 1.5–2.5 mg/kg; maintenance: 4–12 mg/kg/h or 2–6 µg/mL Cpl in target-controlled infusion (TCI) (12)] is often preferred (13). Lately, however, its safety profile during pulmonary surgery has been questioned. One-lung ventilation (OLV) is known to be potentially harmful in terms of alveolar mechanical stress, resulting in proinflammatory cytokines release (14). Anesthetic drugs may have an impact on such response and have been evaluated comparatively: both propofol (15) and halogenated agents (16) have demonstrated immunomodulatory properties, but according to a recent meta-analysis, inhalatory anesthesia is associated to reductions in inflammatory mediators (17) and is therefore to be favored. Unfortunately, this difference has not translated into a survival benefit (18) and its meaning remains uncertain.

The intraoperative opioid should also be chosen both on duration of action and possible side effects. The continuous infusion of remifentanil [induction: 0.5–1 µg/kg in at least 90 sec (19); maintenance 0.05–2 µg/kg/min in association with propofol (20) or 2.5–7 ng/mL Cet in TCI] guarantees effective intraoperative analgesia and rapid extubation times. Some clinicians are reluctant to use it for the possible effects of tolerance and hyperalgesia, but these are unlikely when TCI systems are used (21).

Neuromuscular blocking agents (NMBAs)

NMBAs are used during anesthesia to optimize intubating conditions, mechanical ventilation, and the overall quality of the surgical field. The benefits of a deep blockade have not been demonstrated in thoracic surgery, but it is reasonably desirable, in order to enhance patient's adaptation to the

ventilator and avoid cough or hiccups.

Prevention of residual postoperative paralysis is imperative for all types of surgery and even more so in a fast-track setting, as it could delay recovery and increase the rate of complications. Neuromuscular monitoring with methods such as the train-of-four (TOF) is mandatory with this goal in mind. Evidence shows that patients extubated with a TOF ratio below 0.9 have a higher risk of desaturation, airway obstruction (22), muscular weakness (23), and respiratory complications (24), not to mention longer discharge times from the PACU (25). Residual paralysis is less frequent with drugs of intermediate duration of action and when a reversal drug is used (26). A reversal drug needs to be administered when pre-extubation TOF ratio is less than 0.9. Two options are available: acetylcholinesterase inhibitors and sugammadex. The former are less expensive, but have slower onset times, a ceiling effect (27), and they induce a profound vagal stimulation, or tachycardia when administered with atropine. Moreover, an unjustified use of neostigmine, i.e., its administration with no neuromuscular monitoring, has been associated with an increase in mortality for respiratory causes (28). Sugammadex, on the other hand, is safer, more rapid in blockade reversal, and with no ceiling effect, although it is definitely more expensive and can be used only with NMBAs of the aminosteroid family.

One-lung ventilation (OLV)

Management of OLV has to face two main issues. Intraoperative hypoxemia has always been recognized as a possible complication, due to ventilation/perfusion mismatch. Postoperative acute lung injury (ALI), instead, has become evident only more recently and occurs after 4–15% of lung resections. It afflicts both lungs and is probably the result of multiple factors such as mechanical ventilation, surgical manipulation, oxidative stress, and preoperative chemo- and radiotherapy (29). Strategies to prevent ALI definitely need to be part of any ERAS protocol.

A frequent cause of hypoxemia is the dislocation of the device used for lung separation (30); when desaturation appears, therefore, a fiberscopic verification of its correct placement is the first thing that must be done (31). Traditionally, solutions for prevention and treatment of hypoxemia were the use of high fractions of inspired oxygen (FiO$_2$) and large tidal volumes but no positive end-expiratory pressure (PEEP) nor recruitment maneuvers

(RM). This approach has proved to be dangerous, with a higher incidence of ALI. Unfortunately, while numerous studies have investigated the best ventilatory strategy during two-lung ventilation (TLV), there is less evidence to guide OLV. The primary goal is the prevention of the so-called volutrauma, atelectrauma, barotrauma, and the resulting biotrauma.

Fraction of inspired oxygen (FiO$_2$)

It is reasonable to adopt the lowest possible FiO$_2$, both before and during OLV to reduce resorption atelectasis in the ventilated lung (32) and during re-expansion to reduce the oxidative stress in the non-ventilated one (33). Animal studies have shown an increase in inflammatory mediators when 100% instead of 50% oxygen was used during OLV (34). A consensus on the lowest safe limit of peripheral oxygen saturation to keep during OLV has not been reached; most clinicians try to maintain it above or equal to 90%. Lower values may be accepted for short periods of time in patients without significant comorbidities; when instead limited organ reserves are present, it is prudent to aim at higher targets (35).

Tidal volume (TV)

Protective ventilatory strategies are associated with reduced pulmonary (14) and systemic inflammation (36), improved gas exchange (37), and fewer postoperative pulmonary complications (38,39). Regardless, the optimal TV to adopt is far from clear: 5–6 mL/kg IBW seems reasonable (32), but some authors suggest 4–5 mL/kg IBW (29), although not yet supported by evidence. We still ignore the specific role of low TV in the setting of protective ventilation, which is rather defined by the modulation and interaction of several parameters. The available studies have compared low TVs and high PEEP with high TVs and no PEEP, not allowing to discriminate the contribution of each component on the final result.

Hypercapnia

The use of low TVs often leads to hypercapnia, which seems to exert protective effects against ventilator-induced lung injury (40,41). In a recent study, a PaCO$_2$ of 60–70 mmHg reached during OLV was not only well-tolerated, but linked to reduced post-thoracotomic lung and systemic inflammation (42). It appears reasonable to allow a certain degree of hypercapnia during OLV, except in patients with pulmonary or intracranial hypertension or major arrhythmias.

PEEP

Functional residual capacity ceases to exist with the surgical pneumothorax. The ventilated lung collapses toward the residual volume and its end-expiratory volume becomes dependent on the ventilatory parameters (29). CT scans have demonstrated 80% of atelectasis at end-expiration despite the application of 5 cmH$_2$O of PEEP (43). OLV seems to occur below the closing capacity of the ventilated lung. Strategies to maintain a certain end-expiratory volume are to be preferred. PEEP titration based on dynamic compliance of the respiratory system (with an average result of 10±2 cmH$_2$O) was shown to improve intraoperative oxygenation when compared with a fixed value of 5 cmH$_2$O (44). Experimentally, the highest compliance is reached with a compromise between hyperinflation and recruitment (45,46); this could explain the aforementioned results. The individual contribution of PEEP to ventilator-induced lung injury has not been explored; yet in the absence of adequate PEEP, a low TV has recently been linked to increased postoperative respiratory complications (47), indirectly underlying its importance.

Recruitment maneuvers (RM)

The combined application of a RM during TLV and protective ventilation is associated with reduced cyclic alveolar recruitment-derecruitment and release of inflammatory cytokines (43). Cycling techniques seem to cause less lung stress than sustained pressure holds and vital capacity sighs (48). Better oxygenation, higher compliance, and decreased dead space have been obtained with cycling RM in OLV as well (49). Reasonably, the pressure necessary to recruit a healthy lung should not exceed 40 cmH$_2$O, with a PEEP slowly increasing up to 20 cmH$_2$O. The optimal number of RM to be performed during anesthesia is not clear. In most cases, a single initial RM is sufficient, provided that adequate PEEP is applied. Whether additional RM are to be employed routinely or just in case of desaturation is yet to be determined. A final RM after the re-expansion of the non-ventilated lung is recommended (50), and it should be performed at lower pressure levels in order to prevent damage to surgical staples (49,51).

Modes of ventilation

Studies comparing volume-controlled (VCV) with pressure-controlled ventilation (PCV) during OLV have led to equivocal results in terms of oxygenation (52,53). Some authors support the use of PCV when high airway pressures are reached (51). On the other hand, only VCV guarantees

the delivery of the set TV. Furthermore, elevated peak airway pressures should not be a cause of concern, given the high tube-related resistance during OLV and the similarity of intrabronchial pressures observed with the two modalities (54). Plateau pressures should instead carefully be monitored.

Continuous positive airway pressure (CPAP)

The application of CPAP to the non-ventilated lung has proved useful as a rescue strategy after optimization of ventilatory parameters, to improve oxygenation and allow lower FiO$_2$ (55). Significant results have been reached with levels of CPAP as low as 2 cmH$_2$O (56). Such minimal values can be used even during VATS without affecting the view of the surgical field. Higher pressures would instead cause an insufficient collapse of the non-ventilated lung (57). In addition, a lower inflammatory response has been observed with CPAP (58), probably because of reduced atelectasis and diminished damage during re-expansion.

Locoregional anesthesia

Locoregional anesthesia has a fundamental role in maximizing all potential advantages of mini-invasive techniques like VATS. Thoracic epidural anesthesia (TEA) still represents the standard of reference for the thoracotomic approach (11), but other locoregional techniques have gained popularity in recent times. Due to lack of adequate evidence, a similar consensus on the best approach has not been reached for VATS, although the most recent literature advocates for the thoracic paravertebral block (PVB) (59).

Thoracic epidural anesthesia (TEA)

Epidural block with local anesthetics historically proved a reduced sympathetic response to the surgical stimulus, an improved coagulative profile and a positive influence on endocrine and immune functions (60). It is particularly beneficial in patients with preoperative cardiovascular and respiratory disease (61). Per contra, it features numerous potential complications, both local (epidural hematoma, dural puncture, catheter malposition or rupture, patchy anesthesia, abscess, radiculitis, chronic radicular pain, medullar ischemia, spinal trauma) and systemic (hypotension, respiratory depression, shivering, headache, nausea, urinary retention, intravenous spread of local anesthetic); some represent absolute contraindications limiting its use in specific categories of patients (e.g.,

coagulopathy).

Epidural anesthesia can be obtained with various local anesthetics, alone or associated with opioids (62). Bupivacaine and fentanyl are the most cited in the context of thoracic surgery (63). but the available studies all deal with thoracotomies and are not fast-track oriented. In this setting the association with a low-dose opioid is not recommended because of the higher incidence of adverse reactions. Bupivacaine is commonly used at the 0.25% concentration, with a bolus of 8–15 mL followed by 0.1 mL/kg/h infusion (64,65), yet the 0.125% concentration is also reported, with a 10 mL bolus and infusion at 8 mL/h (66). Levobupivacaine is comparable in terms of sensitive block, hemodynamic response and analgesia, while the safety profile is different (67). These dosages have been investigated for open, thoracotomic procedures. Mini-invasive approaches like VATS are de facto less traumatic thanks to smaller surgical incision and reduced intercostal nerve injury due to stretch by the rib spreader or entrapment during closure of the surgical field, and as such they entail a lower incidence of acute postoperative pain (68,69). Lower concentrations of local anesthetic can therefore be considered, although not yet supported by clinical studies (e.g., bupivacaine 0.125% 0.1 mL/kg bolus and 0.1% 7 mL/h infusion). The same can be said about ropivacaine: in previous reports it was used as 0.75% 5 mL bolus and 0.25% 5 mL infusion (70), more recently it has been effectively employed as 0.2% 5 mL bolus and 5 mL/h infusion at the same concentration (71). With the above considerations, we recommend the latter posology.

Paravertebral block (PVB)
It consists in the infiltration of the local anesthetic in the cuneiform area localized laterally all along the vertebral column, affecting the spinal nerves immediately after their egress from the intervertebral foramina (72). It is often thought of as an "unilateral epidural", owing to its selectivity, even though some degree of epidural diffusion is possible. Somatic and sympathetic nerves are also involved, but the hemodynamic response is less prominent (60). When compared to TEA, the PVB guarantees a similar level of analgesia, fewer complications, a safer profile and better outcomes (60,61,73,74).

PVBs can be performed preoperatively, blindly (with the loss of resistance technique) or with ultrasound guidance (73,75), or intraoperatively by the surgeon under direct view (76). Both single-shot infiltrations with a long-acting local anesthetic and catheter placements for subpleural

continuous infusion are possible (72). Bupivacaine, levobupivacaine, and ropivacaine can all be employed with no evidence of superiority of one over the others (60,61). Bupivacaine and levobupivacaine are typically used at 0.25– 0.5%, ropivacaine at 0.75%. The injected volumes are 5 mL for each paravertebral space, being careful not to exceed the systemic toxic dosage. Continuous infusion is used at the same concentrations (except for ropivacaine, where 0.2% is preferred), with a velocity tailored for each case (around 0.1 mL/kg/h, for a total of 2.5–10 mL/h) (74).

Intercostal nerve block (ICNB)
A thorough knowledge of anatomy is required for this type of block. As for PVB, it can be realized percutaneously (blindly or echo-guided), or "from the inside" by the surgeon, and it contemplates the insertion of a subpleural catheter for continuous infusion. The local anesthetic is normally injected at many levels due to the numerous anastomoses running between adjacent intercostal nerves. To avoid exceeding the safe plasmatic levels of the local anesthetic, the maximum dose is first calculated then adequately diluted to obtain the volumes necessary for the block. Low-dose epinephrine can be added to inhibit systemic absorption and prolong the anesthetic effect. No evidence exists about the local anesthetic of choice for the ICNB; in the available studies bupivacaine 0.5% has been used, with volumes of 1.5–3 mL depending on the number of spaces to be covered (77,78). When compared to TEA and PVB, this block seems to offer a poorer pain control, yet it can still be favored for the lower incidence of adverse events (77).

Serratus anterior plane block (SAPB)
With the recent development and spreading of US-guided peripheral blocks, other techniques involving infiltration of fascial planes infiltration are gaining popularity and are under scrutiny. The SAPB has been recently described by Blanco and colleagues (79). The resulting dermatomal sensory loss extends from T2 to T7 and lasts about 12 hours with the superficial injection and slightly less for deeper infiltration. The effective spreading to the lateral cutaneous branches of the intercostal nerves has been demonstrated using a dye solution (80). Initially suggested for breast surgery, the SAPB associated with catheter positioning for continuous infusion has been successfully used as an alternative to epidural analgesia for multiple rib fracture (81), and as a rescue strategy in case of epidural failure following esophagectomy (82). Its use as technique of choice for

analgesia after thoracotomy (Levobupivacaine 0.25% 20 mL bolus, followed by 0.125% 5 mL/h infusion) seems to offer more hemodynamic stability and overall comparable efficacy when compared to TEA (83). For VATS, the single shot may be suitable (84), but further studies are required to draw definitive conclusions.

Intravenous lidocaine

Intraoperative intravenous administration of lidocaine has been qualifying as a powerful adjuvant for the control of postoperative pain, with favorable results on patients evaluation, opioid consumption, recovery of bowel function, duration of hospitalization, and rehabilitation times, with no evidence of toxicity (85,86).

Lidocaine is a local anesthetic of the amide family, whose principal mechanism of action involves the blockade of voltage-gated sodium channels (19). Other pharmacodynamic properties play a role in its analgesic profile: it presents inhibitory effects on G protein-coupled (87) and NMDA receptors (88), on neutrophil priming (89), and on TNFα signaling in endothelial cells (90). Intravenous infusion of lidocaine has been proposed for chronic pain, especially of the neuropathic type (91), and lately in the perioperative setting, where its adoption appears effective, safe, simple, economical, and widely accessible. Successful results have been reported in abdominal (86), spinal (92), and thoracic surgery (93). In regard to VATS, the only available investigation could not prove an advantage, yet the results may have been jeopardized by an overall low morphine consumption, a short infusion period, and a limited sample size (94). In any case, no adverse events have been reported in any of the mentioned studies, and measured blood concentrations after 1.5 mg/kg bolus followed by 2 mg/kg/h infusion are consistently below toxic levels (85). It appears reasonable to recommend such posology and to limit the postoperative infusion to the period of time in which the patients remain monitored and in a context (e.g., PACU, or intensive care unit) where adverse events would be promptly recognized and treated.

Fluid therapy

A careful management of intraoperative fluid therapy is paramount to optimize postoperative outcome, and even more so in the context of fast-track surgery. Yet it remains nowadays one of the most debated and controversial issues

of patient care. To complicate the matter, scientific evidences on the subject concentrate on other surgical specialties, while those related to thoracic surgery are limited.

Intravascular volume directly affects cardiac output and consequently oxygen delivery. On one hand, excessive fluid administration may lead to overload in the interstitial space, with increased pulmonary complications, delayed recovery (95), and an overall negative impact (96). On the other, hypovolemia can compromise the integrity of surgical anastomoses and the perfusion of vital organs like the kidneys (97). The incidence of acute kidney injury (AKI) after thoracic surgery is 5.9–6.8% (98,99) but can be reduced by hemodynamic optimization with adequate fluid therapy and possibly vasopressor use (100). Urine output should not be used to guide fluid therapy. Intraoperative oliguria is not related to postoperative AKI (101).

The goal of perioperative fluid management should be a fluid balance approximate to zero (102). Perioperative requirements can be satisfied with 1–2 mL/kg/h of crystalloid infusion (103,104). Balanced electrolyte solutions have been proved to be superior to saline for electrolyte homeostasis (105). The hyperchloremic acidosis caused by saline solutions has been linked to a higher risk of renal injury, longer hospital stays and increased 30-day mortality (106). More recent studies have challenged these results, showing that balanced solutions do not guarantee a lower incidence of renal injury (107). Colloids are solutions with a distribution volume mostly limited to the intravascular compartment, with high molecular weight molecules in suspension. They increase the oncotic pressure of plasma and reduce the transcapillary passage of water. Their administration causes greater volemic expansion than crystalloids that instead diffuse freely in the interstitial space. Colloids are associated with a lower incidence of PONV (108). Based on the current data, there is no clear evidence that perioperative colloids promote the development of renal failure (109) and have to be considered equivalent to crystalloids for the intraoperative replenishment of intravascular volume.

Perioperative fluid therapy should be guided by objective measurements of hypovolemia. The so-called goal-directed fluid therapy (110) consists in a rational approach of intravenous fluid administration based on hemodynamic parameters able to predict a positive response (in terms of cardiac output) after volume expansion, avoiding unnecessary loads. Transesophageal Doppler and systems such as Vigileo™ and PiCCO™ have been evaluated during thoracic surgery (111,112). Dynamic indices like stroke

volume variation and pulse pressure variation, derived from the pulse contour analysis of mechanically ventilated patients (113), have been investigated as possible predictors of fluid-responsiveness during OLV. Affirmative results have been observed when TV was set at 8 mL/kg or more (114), which is no longer acceptable in the era of protective ventilation; their predictive value was instead lost when TV was lowered to 6 mL/kg (111). In conclusion, with the open thorax and during protective OLV, invasive arterial pressure monitoring is still recommended, but the reliability of more advanced parameters is poor (115). Thus, it seems reasonable to evaluate the patient's hemodynamics by analyzing the adequacy of oxygen delivery, using indirect variables like blood lactates and central venous oxygen saturation, and to consider vasopressors for the correction of hypotension (116) when it is likely the result of relative drug-induced hypovolemia rather than a real volume deficit. Inotropes should be reserved to patients with an objective assessment of cardiac dysfunction, e.g., as demonstrated by transesophageal echocardiography (117).

In summary, the most relevant evidence-based points (118,119) regarding a correct fluid management are:

❖ Maintain total intravenous fluids during the first 24 hours under 20 mL/kg;

❖ Avoid aggressive fluid administration (under 2 mL/kg/h intraoperatively and 1.5 mL/kg/h in the first 12 hours) and discontinue infusion after resumption of adequate oral intake;

❖ Consider colloids only in case of intraoperative hemorrhage not requiring immediate transfusion of blood products; in any case, a maximum dose of 1 L;

❖ Urine output greater than 0.5 mL/kg/h is not required in the immediate postoperative period, except for patients with preexisting risk factors for development of AKI.

New insights: non-intubated VATS (NI-VATS)

OLV has classically been considered necessary for most thoracic surgical procedures. Recently, advances in VATS have allowed experimentation in non-intubated patients, first for minor interventions (120), then even for major procedures like pneumonectomy (121). With this approach, a recent meta-analysis reported a lower risk of postoperative complications and a shorter mean hospital stay, both in randomized controlled trials and in observational studies (122). At the moment, only one study evaluated the patients' follow-up, with no evidence of a higher rate

of tumor recurrence (123). Overall numbers are scant: in Europe the technique is limited to small operations: 98% of surgeons tried it during surgical evacuation of pleural effusion, while just 26% during decortications for empyema or pulmonary biopsies, and only 2 % for lobectomies (124).

NI-VATS, performed with the patient in spontaneous ventilation, requires an increased anesthesiological effort, the understanding of some peculiar pathophysiological aspects, accurate patient selection, mastery of locoregional techniques, judicious sedation, and rigorous planning of airway management in the event that a switch to general anesthesia and lung separation becomes necessary. Among the advantages of keeping the patient in spontaneous ventilation is the preservation of diaphragmatic activity (125). Lung separation is obtained with the induction of a surgical pneumothorax, although emphysema and pleural adhesions can slow down the resulting lung collapse (126). Lastly, a diminished recourse to anesthetic drugs may help the preservation of hypoxic pulmonary vasoconstriction (126). On the downside, paradoxical breathing (so called pendelluft effect) can develop between the two lungs (125), increasing the risk of hypoxemia and hypercapnia, sometimes so evident to require a switch to general anesthesia, in 1% of patients (127). In most cases, hypercapnia resolves spontaneously, and postoperative $PaCO_2$ is actually lower than after conventional anesthesia (128). Moreover, permissive hypercapnia can have positive results on the general outcome (129). Hypotension, due to the mediastinal shift that occurs during pneumothorax, is a potential issue, but it does not appear to be more relevant than under general anesthesia (130).

Predicted surgical difficulties can be prevailing in patient selection: expected pleural adhesions, extensive resections or interstitial disease advise against the use of NI-VATS (129) while patients of small build and requiring a simple anatomic access are to be favored, at least initially (131). From an anesthesiologist's perspective, ASA class greater than 3 and contraindications to locoregional techniques represent other exclusion criteria (132). Most trials only include patients with optimal pulmonary function tests, yet minor procedures have been brought to completion even in patients with severe respiratory dysfunction (133).

A thorough examination of the technique is beyond the scope of this review. In general, NI-VATS appears a feasible option but it requires a considerable amount of expertise both by surgeon and anesthesiologist, not to mention the whole operating room staff. The observed advantages need to be interpreted in the light of the limited numbers

Table 1 Major anesthesiological elements of the enhanced recovery after surgery program

Intervention	Primary aim
Perioperative period	
Risk assessment	Plan the best anesthesiological approach
Home therapy optimization	Reduce perioperative complications
Avoidance of premedication	Enhance recovery and prevent POCD
Intraoperative period	
Use of short-acting anesthetic drugs	Fasten recovery and reduce side effects
Train-of-four monitoring	Optimize neuromuscular block and its reversal
Protective one-lung ventilation	Prevent ALI
Careful fluid administration	Prevent ALI, optimize tissue perfusion
Locoregional anesthesia	Reduce stress response, pain, and opioid consumption
Prevention of hypothermia	Minimize complications
PONV prophylaxis	Enhance recovery

POCD, postoperative cognitive dysfunction; ALI, acute lung injury; PONV, postoperative nausea and vomit.

(although in rapid expansion) and of its practicability in one's own clinical context.

Conclusions

Anesthesia in the fast-track era is a rapidly evolving subject that requires exceptional attention and continuous update, especially in a delicate setting such as thoracic surgery. Translating scientific evidence into daily practice can be particularly wearying. Moreover, many questions remain open. Fundamental aspects of intraoperative management such as OLV, locoregional anesthesia or fluid therapy are still controversial, although considerable insight has been gained in just a few years and today some light can be shed (*Table 1*). Further research is definitely warranted. Yet many positive results have been accomplished with undeniable satisfaction. We hope this review will be of help to fellow clinicians working every day to enhance their patients' recovery after thoracic surgery.

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Footnote

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Enhanced recovery pathways in thoracic surgery from Italian VATS Group: perioperative analgesia protocols

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Abstract: Video-assisted thoracoscopic surgery (VATS) is a minimally invasive technique that allows a faster recovery after thoracic surgery. Although enhanced recovery after surgery (ERAS) principles seem reasonably applicable to thoracic surgery, there is little literature on the application of such a strategy in this context. In regard to pain management, ERAS pathways promote the adoption of a multimodal strategy, tailored to the patients. This approach is based on combining systemic and loco-regional analgesia to favour opioid-sparing strategies. Thoracic paravertebral block is considered the first-line loco-regional technique for VATS. Other techniques include intercostal nerve block and serratus anterior plane block. Nonsteroidal anti-inflammatory drugs and paracetamol are essential part of the multimodal treatment of pain. Also, adjuvant drugs can be useful as opioid-sparing agents. Nevertheless, the treatment of postoperative pain must take into account opioid agents too, if necessary. All above is useful for careful planning and execution of a multimodal analgesic treatment to enhance the recovery of patients. This article summarizes the most recent evidences from literature and authors' experiences on perioperative multimodal analgesia principles for implementing an ERAS program after VATS lobectomy.

Keywords: Regional analgesia; pain management; video-assisted thoracoscopic surgery (VATS)

Introduction

Enhanced Recovery After Surgery (ERAS) is a multimodal, multidisciplinary approach to surgical patients with the aim of enhancing the quality of recovery after surgery (1,2). This strategy translates into faster post-operative recovery and improvements of outcomes. All the ERAS Society guidelines (freely available at www.erassociety.org) take into consideration the perioperative management of analgesia. The role of pain management in ERAS pathways is fundamental, considering the importance of containing surgical stress, reducing pain-related complications and speeding recovery (2-5).

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Although the ERAS principles seem reasonably applicable to thoracic surgery, there is little literature on the application of such a strategy in this context. For certain, the evolution of minimally invasive thoracic surgery has created a more favourable framework for the drafting of ERAS programs. In regard to pain management, it promotes the adoption of a multimodal strategy, tailored to the patients. Yet there is currently no consensus on the best strategy for treating pain after video-assisted thoracoscopic surgery (VATS) (6). Despite the reduced invasiveness when compared to the thoracotomic approach, postoperative pain after VATS must still be considered moderate-severe (7,8).

This article summarizes the most recent evidences from literature and authors' experiences on perioperative multimodal analgesia principles for implementing an ERAS program after VATS lobectomy. Some technical or pharmacological aspects of pain therapy and postoperative nausea and vomit prevention are not herein discussed because already analyzed in other articles included in this issue of the journal.

Multimodal analgesia strategy

Multimodal analgesia is the most effective strategy to improve pain relief and reduce the side effects of every single agent (4,9,10). It is based on the use of a variety of analgesic agents and/or techniques that target different nociceptive mechanisms. The latest comprehensive guidelines on postoperative analgesia, published in 2016 by the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' Committee on Regional Anesthesia, strongly recommends that clinicians offer multimodal analgesia for the treatment of postoperative pain in both children and adults (strong recommendation, high-quality evidence) (9). Back in 2010, the Italian Society of Anesthesia, Analgesia and Intensive Care (SIAARTI) already recommended the adoption of multimodal analgesic strategies and underlined the importance of their adjustment to fast-track surgical settings (10). Recent reviews on analgesic care in ERAS protocols report the same concept, highlighting the necessity of combining systemic and loco-regional analgesia to favour opioid-sparing strategies (4,5,11). The latter goal is extremely important, to minimize not only the side effects of this pharmacological class, but also the risk of respiratory

complications of patients undergoing thoracic surgery.

Systemic intravenous analgesia

Systemic analgesia is a fundamental component of any multimodal approach. The administration of analgesic drugs must be scheduled and include a rescue strategy for inadequate pain relief (10).

Opioids

Opioids have largely been used for pain management after thoracic surgery because of its severity. Pre-emptive administration of these agents is no longer recommended (9,12). Given the wide interindividual response, metabolism and elimination of opioids, their administration should be delivered via patient-controlled analgesia (PCA) devices (9) avoiding intravenous continuous infusion or intramuscular administration of opioids. Obviously, impaired cognitive function contraindicates PCA use (9). Finally, routine basal infusion of opioids with PCA must be avoided in opioid-naive patients because it increases the risk of side effects (9,13-16). Opioid-related side effects are in fact numerous, and include hypotension, respiratory depression, itching, nausea and vomit, bowel ileus, confusion and sedation (16,17). For these reasons, whenever possible, the use of opioids should be avoided or at least reduced to enhance recovery after VATS lobectomy. However, opioids still represent a significant component of pain therapy, and can be administered as a rescue analgesic when other non-opioid analgesics fail.

Morphine is the most used opioid for pain management after surgery. It has an onset time of about 30 minutes and a duration of action of 4–6 h after intravenous administration (18,19). Some of its metabolites are actually more active than morphine itself and can accumulate in case of kidney failure (18), so its clinical effect must be carefully monitored. During PCA administration, the typical dose is 1–2 mg bolus with a lock-out interval of 6–12 minutes (15,16,20).

Fentanyl and sufentanil are powerful lipophilic opioids with faster onset time and shorter duration of action when compared with morphine. Fentanyl is frequently used as the intraoperative opioid of choice. Both fentanyl and sufentanil can technically be used for PCA, but no robust data is available on their use for acute pain management

after thoracic surgery. Conversely, their use is common in combination with local anesthetics as part of epidural analgesia. Recently, a sufentanil sublingual tablet system has been proposed as a novel PCA device (21,22). It delivers 15 mcg of sufentanil with a lock-out interval of 20 minutes. This non-invasive PCA system is attractive and potentially adapt to an ERAS program but no data is currently available in regard to thoracic surgery.

Oxycodone is another opioid administered via the oral route with an onset time of 1–2 h and a duration of action of 4 h. Its use has been successfully proposed for postoperative pain management of patients undergoing thoracoscopic surgery once they have resumed oral intake (23).

Given the reduced invasiveness of VATS procedures, weak opioids are suitable for postoperative acute pain, if associated with a proper loco-regional technique. Codeine is extensively used for the treatment of moderate pain. It is usually administered via oral route combined with paracetamol to exploit their synergistic effect (24,25). Tramadol can instead be used intravenously in the immediate postoperative period. It produces analgesia through two mechanisms of action: mu-opioid receptor activation and serotonin and norepinephrine reuptake inhibition. It must be noticed that the concomitant use of ondansetron, a commonly associated antiemetic agent, can reduce its efficacy due to its effect on serotonin receptors (26). Tramadol is usually administered intravenously (100 mg every 6–8 h) or orally (50–100 mg every 6–8 h) for the treatment of mild and moderate pain, and is also useful for the prosecution of an analgesic therapy based on a strong opioid (i.e., morphine).

Nonsteroidal anti-inflammatory drugs (NSAIDs)

NSAIDs administration reduces opioids demand of 30–35% (27). They increase the risk of kidney failure, gastric bleeding and have antiaggregant platelets effect. Recently, a meta-analysis has denied its role in increasing bleeding risk after surgery (28). There are no specific data on this topic as regard thoracic surgery but there is no reason to hypothesize the contrary. Nowadays, ketorolac is the most used NSAID in the postoperative phase. Its posology is 30 mg i.v. every 8 h for 2 days (29). Ketorolac and diclofenac have both shown efficacy after VATS, with comparable results (30). Indomethacin has been

associated with a better pain relief after thoracotomy (31) but its use is uncommon in this context.

Paracetamol

Like NSAIDs, paracetamol enhances analgesia and produces an opioid-sparing effect, reducing postoperative postoperative nausea and vomiting (PONV) and sedation (32-35). It is well tolerated and not burdened by NSAID-like side effects. Its only limit is the potential for hepatotoxicity but at doses of more than 4 g per day. Moreover, a randomized controlled trial (RCT) showed a decrease of postoperative ipsilateral shoulder pain after thoracotomy (36). The intravenous dosage for postoperative pain is 1 g every 6–8 h. Given its safe pharmacodynamic profile and its synergic effect with other analgesics, paracetamol must be considered as a first choice in a multimodal analgesic protocol.

N-methyl-D-aspartate (NMDA) antagonists

The inhibition of NMDA receptors decreases postoperative pain and opioid consumption (9). Ketamine is used at sub-anesthetic doses as an infusion during and after surgery. It can reduce intravenous PCA morphine use and PONV (37). Although it happens rarely, one must consider that it can cause dysphoria. Magnesium sulphate is another NMDA antagonist that can decrease postoperative pain and opioid consumption (38).

Dexamethasone

Dexamethasone is a steroid agent useful for PONV prevention (10). A recent meta-analysis demonstrated that it also decreases postoperative pain and opioid consumption (39). Particularly, the 8-mg dose does not seem to be superior than the 4 mg one.

Lidocaine

Lidocaine hydrochloride is a short acting local anesthetic that can be administered as an intravenous infusion during and after surgery. Its use is implemented in many ERAS program (5). The infusion of lidocaine for thoracotomy has resulted in reduced pain and morphine consumption in the

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first 6 h after intervention (40). Unfortunately, this result was not confirmed after VATS surgery (41). Given the lack of evidence of lidocaine's efficacy in this context, it seems reasonable to consider it as a second line treatment.

Gabapentinoids

Gabapentinoids (gabapentin and pregabalin) are antiepileptic agents commonly used to treat neuropathic pain. Their use has been proposed as opioid-sparing agents and to prevent the insurgence of post-thoracotomy neuropathic pain. Meta-analyses indicate that preoperative administration of gabapentinoids may also reduce postoperative pain and opioid consumption (42,43). Preoperative gabapentin before thoracotomy has not shown to reduce pain, opioid consumption nor the prevalence of neuropathic pain at 3 months after surgery (44). Conversely, pregabalin has demonstrated promising results in terms of post-thoracotomy neuropathic pain (45,46). There is no data concerning the use of gabapentinoids in the context of VATS surgery. Both agents (especially gabapentin) are associated with sedation, dizziness, and visual disturbances. Considering these side effects, gabapentinoids must be used with caution and cannot be recommended for routine use in ERAS protocols, especially in elderly patients.

Loco-regional analgesia

Thoracic epidural analgesia (TEA)

TEA is considered the gold standard technique for pain management after thoracic surgery (47,48) and recommended as first choice in many ERAS protocols for other surgeries (especially for open surgical cases) (4,5). It provides a better pain relief than opioid PCA treatment and promotes recovery. Opioids can be associated to local anesthetics to increase the efficacy of epidural analgesia. Along with TEA's effectiveness, its invasiveness must be taken into account, which might limit its use in some circumstances (i.e., use of anticoagulants). TEA has several other limitations: the placement of thoracic epidural catheter can be challenging, there is a need for adequate skilled care providers for its perioperative management, and it can cause sympathetic blockade, respiratory depression, urinary retention and, rarely, local complications both during and after procedure. Today, the most used local

anesthetics for postoperative TEA are ropivacaine 0.2% and levobupivacaine 0.125% at an infusion rate usually between 6–10 mL/h.

Thoracic paravertebral block (TPVB)

In the context of mini-invasive surgical approaches, such as VATS lobectomy, it becomes imperative to evaluate the risk-benefit ratio of any invasive loco-regional technique. In the last 15 years, the TPVB has grown in popularity and it is now increasingly proposed as an alternative to TEA. It is comparable to TEA, but associated with less side effects (49) and an improved safety profile (50). A recent meta-analysis has equalized it to TEA with respect to pain relief, major complications, length of hospital stay and 30-day mortality for patients undergoing thoracotomy (49).

The single-shot TPVB was effective for pain control after VATS mainly in the immediate postoperative period in several studies (51). For an adequate postoperative pain management, it needs to be associated with an opioid-based PCA, as commonly done in UK (52). Alternatively, a longer analgesic coverage can be obtained with the continuous TPVB, i.e., the infusion of local anesthetics via a catheter placed in the paravertebral space (53).

The TPVB can be performed with the blind technique, the ultrasound-guided approach or intraoperatively by the surgeon. Currently, no study has compared these techniques but the ultrasound-guided one is reasonably the most accurate and safe approach. The TPVB is easier and safer than TEA to perform, but it is not devoid of possible complications such as pneumothorax, hemodynamic compromise, or total spinal anesthesia (54-58). Thus, new approaches to the TPVB for breast surgery have been proposed: the retrolaminar block (RLB) and the mid-point transverse process to pleura block (MTP block) (59,60). In both cases, the local anesthetic is injected near the paravertebral space providing similar effect. A clear limitation of these techniques appears the inability to place a catheter for continuous postoperative infusion. At the current time, we do not recommend RLB and MTP blocks for pain management after VATS.

The best local anesthetic concentration for TPVB is not known, it ranges between bupivacaine 0.1–0.25% at 5–12 mL/h to ropivacaine 0.2% at 4 mL/h (18). The addition of clonidine or fentanyl to the TPVB has not shown benefit after thoracotomy (61) and is not recommended.

Intercostal nerve block (ICNB)

ICNB is a well-known, fairly simple technique for pain management after thoracotomy (47). Both the single-shot technique and the continuous infusion are possible, but only the latter seems effective after thoracic surgery (62). Other successful strategies contemplate the use of liposomal formulations (63,64). The continuous infusion of local anesthetic in the intercostal space provides adequate pain relief, comparable to TEA, until the 5th postoperative days after thoracotomy (65). After VATS, it is effective for up to 16 h and reduces morphine consumption for the first 24 h (53). In conclusion, ICNB is suitable in combination with PCA therapy when TEA or TPVB have not been performed (47).

Serratus anterior plane block (SAPB)

The SAPB was originally proposed for breast surgery (66) but its applications have later been extended, and is now often used in thoracic surgery. It is an ultrasound-guided thoracic wall nerve block that covers the lateral cutaneous branch of the intercostal nerves from T2 to T9 (67). The SAPB provides more hemodynamic stability compared with TEA after thoracotomy (68) and potentiates PCA analgesia reducing pain and morphine consumption (69). In the first study, a loading dose of levobupivacaine 0.25% 30 mL was followed by a continuous infusion at 5 mL/h (with levobupivacaine 0.125%). Furthermore, in a small randomized trial comparing tramadol-based PCA *vs.* tramadol-based PCA plus single-shot SAPB (bupivacaine 0.25% 20 mL) in patients undergoing VATS, the loco-regional technique reduced pain and opioid consumption in the first 24 h after intervention (70). The limited invasiveness of this technique is intriguing for VATS but, despite the promising results, more studies are needed to confirm its effective potential in this context. However, the SAPB, along with the ICNB, can be considered as a second choice whenever the TPVB is not feasible. It can also be implemented before the surgical incision, and associated with the TPVB performed intraoperatively by the surgeon under direct view.

Erector spinae plane block (ESPB)

The ESPB is a newly described technique for providing thoracic anesthesia (71). Under ultrasound guidance, about 20 mL of local anesthetic are injected 3 cm beside the interspinous line at T5 level deep to the trapezius, rhomboid and erector spinae muscles. ESPB has been proposed for thoracic neuropathic pain, rib fractures and as rescue in thoracotomy after epidural failure (72-74). Currently, the lack of experience with this technique does not allow to define its role in the treatment of pain after VATS and hence its use is not yet recommended.

From acute to chronic pain

Chronic postsurgical pain is a common and serious complication after thoracic surgery [post-thoracotomy pain syndrome (PTPS)] (50,75). Risk factors for the PTPS include female gender, young age, anxiety, and depression. Its prevalence is extremely variable, ranging from 9% to 80% after thoracotomy and from 5% to 33% after VATS (76). This difference between different surgical approaches is not widely accepted (77). Intraoperative ketamine has not demonstrated any protective effect over PTPS (17). Similarly, there is no conclusive data in regard to gabapentinoids for the prevention of chronic postsurgical pain, even though pregabalin has shown promising results after thoracotomy (48,49).

Today, an adequate postoperative pain relief together with the inhibition of afferent pain transmission is considered the best way to prevent PTPS (50,78,79). From this point of view, loco-regional techniques play a primary role and must be considered an indispensable part of the multimodal pain therapy.

Conclusions

Effective perioperative pain management is a crucial part of any ERAS program. Careful planning and execution of the analgesic treatment, based on a multimodal approach, is mandatory to enhance the recovery of patients (*Figure 1*). The wide range of loco-regional analgesia techniques for thoracic surgery contributes to achieve this goal. So, we strongly suggest that all patients receive the administration of a local anesthetic through one of the techniques discussed in this article as an integral part of the VATS surgery's analgesic protocol.
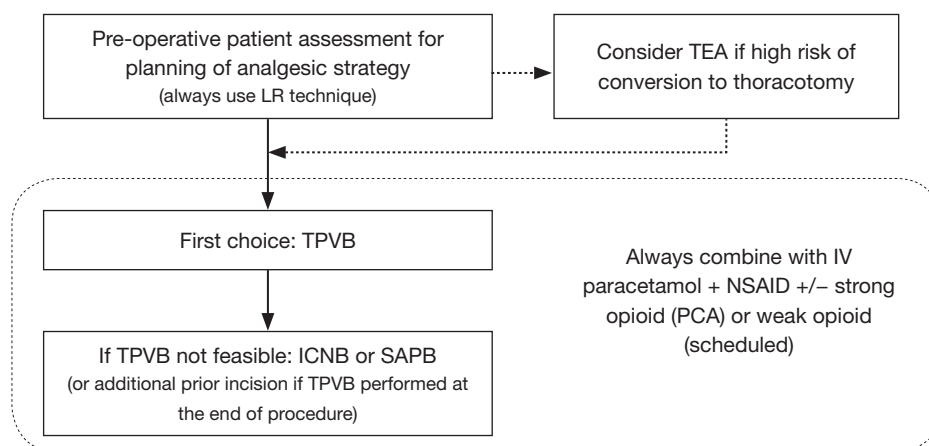
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Figure 1 Schematic representation of post-operative pain management strategy after VATS lobectomy. The pre-operative patient assessment allows to set the analgesic plan. The cornerstone is always the inclusion of a loco-regional technique. Thoracic epidural analgesia should be considered if there is a high risk of conversion to thoracotomy. Otherwise thoracic paravertebral block is considered the first-line loco-regional technique. If not feasible, it can be replaced with intercostal nerve block or serratus anterior plane block. These techniques must be always integrated with systemic analgesia to meet the criteria of multimodal analgesia. LR, loco-regional; TEA, thoracic epidural analgesia; TPVB, thoracic paravertebral block; ICNB, intercostal nerve block; SAPB, serratus anterior plane block; NSAID, nonsteroidal anti-inflammatory drug; PCA, patient-controlled analgesia; VATS, video-assisted thoracoscopic surgery.

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Footnote

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Enhanced recovery after surgery and video-assisted thoracic surgery lobectomy: the Italian VATS Group* surgical protocol

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Abstract: Enhanced recovery after surgery (ERAS®) is a strategy that seeks to reduce patients' perioperative stress response, thereby reducing potential complications, decreasing hospital length of stay and enabling patients to return more quickly to their baseline functional status. The concept was introduced in the late 1990s and was first adopted in patients undergoing open colorectal surgery. Since then, the concept of ERAS has been adopted by multiple surgical specialties. The diffusion of video-assisted thoracic surgery lobectomy (VATS-L) sets also the surgical treatment of lung cancer as a new area for ERAS development. In this paper, we present the Italian VATS Group (www.vatsgroup.org) surgical protocol as part of the ERAS clinical pathway belonging to the VATS-L national database.

Keywords: Enhanced recovery after surgery (ERAS); video-assisted thoracic surgery lobectomy (VATS-L); lung cancer

Introduction

Enhanced recovery after surgery (ERAS) is a strategy that seeks to reduce patients' perioperative stress response, thereby reducing potential complications, decreasing hospital length of stay, and enabling patients to return more quickly to their baseline functional status. With the diffusion of video-assisted thoracic surgery lobectomy (VATS-L), the surgical treatment of lung cancer became a new area for the development of ERAS. The ERAS clinical pathway for VATS-L provides also a surgical protocol with clinical recommendations about the specific aspects closely related to the surgical technique and to the management

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Table 1 Recommendations and suggestion for intraoperative management during VATS lobectomy are schematized

Field of application	Recommendation
Access/trocar numbers	VATS-U >> VATS standard (2/3 ports)
Parenchymal mobilization	Recommended
Pleural tent	Recommended only in selected cases (i.e., severe emphysema)
Surgical sealant	Recommended in case of intraoperative air leak
Staple-line reinforcement	Recommended only in selected cases (i.e., severe emphysema)
"Fissure-less" technique	Not recommended; left to the surgeon's choice
Number of pleural drains	Recommended the use of one drainage

VATS-U, uniportal VATS; VATS, video-assisted thoracic surgery.

of chest drainage and other invasive devices (1). Following we present the Italian VATS Group (www.vatsgroup.org) surgical protocol as part of the ERAS project belonging to the VATS-L national database.

ERAS and VATS-L

The surgical aspects closely related to VATS-L to be defined in an ERAS protocol can be identified in the intra and post-operative phase, as it follows:

❖ Intra-operative phase: technical aspects designed to achieve maximum reduction of trauma and complications;

❖ Post-operative phase: management and removal criteria for pleural drains and other invasive devices [e.g., nasogastric tube (NGT), central venous catheter (CVC), urinary catheter, arterial catheter].

Intra-operative surgical aspects

The minimally invasive approach to pulmonary resections is considered the best surgical approach to early stage non-small cell lung cancer (NSCLC), showing several advantages over traditional open surgery in terms of postoperative outcomes (2). In order to minimize the surgical trauma and stress during a VATS-L, we identified three fields of action, resumed in *Table 1*: the minimal invasiveness of VATS (i.e., number of ports/access); the intraoperative strategies for air leak prevention; the number of pleural drainage.

Minimally invasiveness of VATS approach—number of ports and/or thoracic accesses

The minimal invasiveness of VATS-L is based on the lower impact of its surgical trauma compared to traditional open

thoracotomy. The VATS group adopted the universally accepted definition of VATS-L as a procedure without rib spreading, with thoracoscopic vision and a separate dissection of the hilar structures (www.vatsgroup.org). However, several techniques of VATS-L have been described over the years, differing mainly on the number of ports and their location. The number of ports can be discussed as a factor affecting the invasiveness of the surgical procedure and consequently influencing the postoperative functional recovery.

Three- or bi-portal VATS versus mono-portal VATS

The transition from a standard multi-portal to a mono-portal VATS approach has been reported by several authors as a viable strategy to improve post-operative outcomes, in terms of pain, length of stay and morbidity. This can potentially be translated into a reduction of post-operative hospitalization and faster recovery of patient's daily activities, which is the goal of ERAS program. A recent meta-analysis by Harris *et al.* (3) compares the outcomes of n=627 multi-portal versus n=1,223 uni-portal VATS lobectomies for lung cancer from eight observational studies published over the past 2 years; the results showed statistically significant differences in favour of uni-portal VATS in terms of hospital stay (6.2±2.6 *vs.* 6.7±3.4 days, P<0.0001), chest drain duration (4.5±2.2 *vs.* 5.4±2.9 days, P=0.0006) and postoperative complications (12.0% *vs.* 13.7%, P=0.009); also postoperative pain was found to be reduced in mono-portal procedures but without any statistical significance. To further confirm this data, a recent study by Tamura *et al.* (4) has shown how single-port technique reduces postoperative pain and increases quality of life in the perioperative period. Again, if we look at the residual pain and paresthesia, Jutley

et al. (5) and Gonfiotti *et al.* (6) showed data in favour of mono-portal VATS. Although further randomized studies are needed to validate all the benefits of a mono-portal approach, in our opinion there is sufficient data to assume that also in the field of VATS-L, a lesser surgical trauma on the chest wall may result in a faster functional recovery. In the surgical chapter of our ERAS protocol, we included all the VATS-L techniques described in the VATS Group database (i.e., three-, bi- and mono-portal) but we suggested to shift toward a reduction of port number.

Air leak prevention

A postoperative air leak is defined by air escaping the lung parenchyma into the pleural space after any kind of surgery in the chest. The literature defines a prolonged air leak (PAL) as an air leak lasting beyond postoperative day 5. PAL is associated with a worse postoperative course, prolonged hospital stay and increased costs. Some authors therefore consider any PAL as a surgical complication. Prevention of a PAL is crucial from an ERAS perspective. In several reports from the Italian VATS group database, the incidence of PAL is reported in up to 7.2% of patients and this result is consistent with other large series (7,8).

In addition to this evidence, further studies have shown that PAL is associated with an increased risk of postoperative complications. Brunelli *et al.* (9) reported a higher rate of pleural empyema in patients with PAL; similarly, Varela and colleagues (10) have shown that an air leak beyond the 5th postoperative day is associated with an increased risk of atelectasis, pneumonia and pleural effusion.

Several surgical strategies have been developed to prevent PAL, mainly adopting two different strategies: reducing the residual pleural space or reinforcing/protecting the parenchymal suture line. The routinary use of these procedures is not recommended since there isn't a clear evidence of their utility and some of them (i.e., lung sealants) are quite expansive.

The following air leak prevention strategies were taken into account and analysed in our ERAS protocol:

❖ Pulmonary mobilization: this is an effective strategy for the prevention of PAL, especially after lobar resection. There are several techniques used for this purpose: the simplest and most commonly practiced is the lysis of all pleuro-parenchymal adhesions and pulmonary ligament;

❖ Pleural tent: creating an apical pleural tent during upper lobectomy or superior bilobectomy is a proven technique to decrease the risk of PAL. The pleural tent is created by removing the parietal pleura from the endothoracic fascia, starting from one of the thoracic access in a circumferential and apical direction. Three randomized trials demonstrated that a pleural tent created at the time of pulmonary resection may significantly decrease the duration of chest drainage and hospitalization (11), reduce the incidence of postoperative air leak (12), decrease air leak and chest drain duration, as well as hospitalization and hospitality costs (13);

❖ Surgical sealant: in 2010 a review of the Cochrane Database evaluating the use of surgical sealants for the prevention or reduction of postoperative air leak included 16 randomized trials and 1,642 patients (14): six studies showed a statistically significant reduction of air leak duration in the treatment group while three studies showed also a significant reduction in chest drain duration. On the contrary, no study showed a reduction of length of stay. On this basis, the routine use of surgical sealants is nowadays not recommended. However, several studies showed a positive trend in shortening both, chest drain duration and hospital stay, even if without statistical significance (15); on the other hand, most part of these studies do not include the use of a digital drainage system and the policy to remove the drainage based on liquid production, is often quite conservative (16,17). As a consequence, the failure in moving the benefit of the sealant from the air leak duration to the chest drain removal and length of stay, could be the result of a bad chest drain management. We therefore believe that the use of sealants could be useful in a fast-tracking program; we speculate that with the use of digital drainage system and within an ERAS protocol, this bias could be deleted mainly reducing the time discrepancy between the end of the air leak and the removal of chest drain, often linked to a "traditional" post-operative drain management which is far from an "enhanced recovery" philosophy. In our ERAS protocol we suggested the use of sealants in case of intraoperative air leak observed during the inflation test after lung resection has been completed;

❖ Reinforced staple-line: the use of reinforced staple-lines has shown variable results. In patients with severe emphysema undergoing lung resection, several randomized trials suggest the effectiveness of staple line reinforcement in reducing the incidence of air leak, chest drain duration and hospital stay

Table 2 Recommendations and suggestion for postoperative chest tube management after VATS-L

Field of application	Recommendation
Digital drainage system	Recommended
Continuous suction	Recommended for the first 24 h
Drain removal according to fluid production	<5 mL/kg/24 h in case serous liquid
Drain removal according to air leak	Recommended after 6 h of absence and/or <40 mL/min on digital drain system

VATS-L, video-assisted thoracic surgery lobectomy.

(18,19); this indication is confirmed also in case of non-anatomic lung resections in patients with a high risk of PAL and/or FEV1 <60% of predicted (8). Outside the field of severe emphysema, the utility of reinforced staple line in lung anatomical resections has not been demonstrated (20). In our surgical protocol, we suggested to reinforce the suture line during completion of the fissure only in case of an associated diffuse emphysema;

❖ Other techniques for post-operative air leak prevention, our protocol also included the following suggestions:
  ♦ Minimal dissection of interlobar fissures;
  ♦ Avoid the overlap of suture lines;
  ♦ Slow closure of the stapling device in thick parenchymal tissue.

Another potentially useful approach is the "fissure-less" technique used during VATS-L. Central aspect of this technique is to avoid dissection of incomplete fissures, reducing the risk of parenchymal lesions and consequently of PAL. The fissureless technique has been described for the first time by Temes *et al.* (21) and then used during VATS-L by Nomori *et al.* (22) and Loran *et al.* (23). In a recent best evidence topic in cardiothoracic surgery (24), out of five selected papers, four demonstrated the fissureless technique used in pulmonary lobectomy was superior to conventional lobectomy (CL) in terms of preventing PAL and shortening the time to air leak cessation. The paper concluded that current evidence demonstrates the fissureless technique as significantly better than CL (25). However, even if the fissureless technique is almost universally accepted in upper or middle lobe lobectomies, it has been criticized when used during lower lobectomies, mainly for oncological reasons as it could reduce the effectiveness of VATS lymph node dissection of N1 stations (26). For these reasons we decided to suggest the use of fissureless technique in our ERAS VATS-L protocol, even if we do not consider this choice as

mandatory.

Number of pleural drains

According to fast-tracking, the VATS Group ERAS program suggested using just one pleural drainage (28/30 Fr) instead of two after pulmonary lobectomy; placement of the second tube is to be considered when a significant postoperative air leak is predicted or after a bi-lobectomy (27). A single chest drain, by reducing p.o. chest pain, allows an early and easier patient mobilization, which is the goal of the ERAS program (28,29).

Postoperative surgical aspects: chest drain management

The ideal chest tube management protocol has yet to be determined (30-32). The review of the literature indicates that clinical decisions are often based on institutional practices, physician training, and preferences developed from experience (33). The timing and parameters for chest tubes removal, the need for postoperative suction are still the subject of debate. Optimizing the duration of chest tube drainage after lung resection is crucial for improving quality of care, shortening the hospital stay and reducing costs (10, 34-35).

In developing our ERAS protocol, we discussed three main aspects about chest tube management: (I) deciding whether suction should be applied to chest tubes and its duration; (II) selecting fluid output threshold for the removal of chest tubes; (III) deciding how long after the cessation (observed or digitally recorded) of an air leak the chest tubes should be removed. The chest tube management protocol is resumed in *Table 2*.

Chest drain suction application and duration

The optimal management of suction is a source of continued debate, and thoracic surgeons are usually divided between two different theories: (I) suction applied to chest tubes prolongs air leaks by increasing the amount of air escaping from parenchyma, or (II) suction applied to chest

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tubes decreases the amount of residual space, promoting pleural apposition and healing.

Cerfolio et al. (36) and Marshall et al. (37) supported the first theory that placing chest tubes on water seal is better than suction for reducing air leaks. On the contrary, Brunelli et al. (38) first observed no advantage with the use of the water seal compared with suction in patients undergoing lobectomy, and in 2005 (39) proposed an alternating strategy of less forceful suction (–10 cmH₂O) overnight and water seal during the day. This approach after lobectomy seemed to reduce the incidence of PAL, chest tube duration and postoperative hospital stay. Since our scope was not to support one of the two theories, in the ERAS protocol we recommended postoperative suction for the first 24 h, which is widely accepted, avoiding a prolonged (>24 h) suction maintenance which may be less effective than simple water seal (40,41). Our ERAS protocol indicates the use of a traditional or digitally monitored thoracic drainage system with a set pressure level of –20 cmH₂O immediately after the operation until the first 24 h postoperatively.

Liquid production

The removal of chest tubes based on the production of fluid is controversial since it's based primarily on tradition and dogma more than on clinical studies. Many surgeons use a very conservative range in daily liquid production, such as 150 cm³/day or lower. Recently, several authors suggested that the removal of chest tubes draining 400–450 cm³ of serous fluid drainage per day is safe while a large consensus statement defined a safe threshold at 300 cm³/day (40-42). However, the physiology and pathophysiology of the pleural space always refers to a liquid content and a daily replacement which is quantified in cm³/kg (43). Several authors pointed out that a cut-off of 3 up to 5 cm³/kg of serous liquid appears to be a reasonable threshold it sits within the range of physiological daily pleural fluid filtration and it is suitable for an early chest drain removal without increasing complications and re-admission rates (44).

Based on these clinical evidences, in our ERAS surgical protocol we indicated the removal of chest tube with 5 cm³/Kg of fluid drainage/day or less in case of serous pleural liquid.

Air leak

The absence of an air leak is considered the most important parameter for chest drain removal.

The clinical practice is traditionally to remove chest tubes between 12 and 24 h after the end of air leaks.

However, this timing is often arbitrary, depending on the observation intervals and on the subjective assessment; moreover, several air leak grading systems are available and used in the clinical practice (36,45).

About observation intervals, it is difficult to plan a time frame able to capture the precise moment of air leak cessation; usually the frequency of observations depends on clinical progress and medical request, with intervals of at least 4 h. As a consequence, the 24 h of "no observed air leak", may result from a longer period of air leak absence. This bias usually adversely affects the fast track process, delaying chest drain removal and prolonging hospital stay.

Because traditional drainage systems measure and grade air leaks in a subjective manner, interobserver disagreement on the presence of an air leak is frequent (46). The traditional policy allows chest drain removal only after a period of absence of air leak on coughing as assessed by underwater seal. However, an occasional "bubble" can be noted by different surgeons, sometimes leading to a further 24 h of drain duration.

The introduction in clinical practice of digital drains has allowed to overcome most part of these problems. Using digitally monitored thoracic drainage systems air leakage and pleural pressure can be objectively measured, the presence and rate of air leakage per minute can be seen on a display in real time and the digital data for air leakage and pleural pressure can be retrospectively analyzed (47), confirming the duration in which the air leak has stopped and differentiating between no air-leak and a blocked drain. Another important contribution of digital drainage systems is the paradigm shift that allows the drain to be safely removed in the presence of a continuing (small) air-leak. Furthermore, digital drains comprise a portable system for suction and allow the maintaining of a constant intrapleural negative pressure without limiting an early patient mobilization.

To date, several prospective studies have been published about the real benefits of digital drainages, showing advantages in terms of pulmonary re-expansion, chest drain duration and hospital stay (36-38).

Moreover, with the use of these new devices, the criteria for chest drain removal have been progressively redesigned, and have become more permissive.

Mesa-Guzman et al. demonstrated that a permissive chest digital drain removal protocol allowed the objective removal of drains earlier, reducing hospital stay for patients and costs for the hospital without increasing post-drain removal complications (44).

Based on these new clinical evidences (48), we adopted permissive criteria for chest drain removal after air leak cessation; the ERAS protocol suggest an interval of 6 h of no "observed" air leak in case of traditional drains or, if a digital drainage system is used, the threshold of an air leakage less than 20 mL/min for more than 6 h.

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Footnote

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VATS Group ERAS Registry

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Abstract: Enhanced recovery after surgery (ERAS) is a multimodal, polyhedral approach to surgical management for patients undergoing surgical therapy. Since ERAS is not a specific procedure, these protocols are not exclusively created for particular clinical settings but they are prone to be adapted to a large variety of healthcare programs after surgery. ERAS Society was the platform in which a new multidisciplinary methodology to promote a fast recovery, a considerable patient involvement and resource optimization has been developed. ERAS Society has also produced guidelines for different surgical specialties and has already generated some evidence regarding preoperative, intraoperative and postoperative practice. ERAS in Thoracic Surgery has had a slow-growing development but some hints suggest that introducing ERAS methodology in pulmonary resections for cancer could be feasible and effective with potential tangible benefits for patients, families, caregivers and welfare. There is no evidence yet concerning ERAS principles in Thoracic Surgery; for this reason, a new possibility for prospective data collection and analysis is created using the VATS Group Web Registry in which additional records, documents and facts have now the possibility to be registered and eventually explored to possibly adjust the ERAS protocols to major pulmonary resections.

Keywords: Lung resection; fast recovery; videothoracoscopy; registry

Introduction

Enhanced recovery after surgery (ERAS) program was first illustrated by Henrik Kehlet in 1997 with the specific interest for quality improvement of perioperative protocols (1). The ERAS principles have then become a Society with progressive interest and support in generating guidelines and programs for a fast recovery after surgery. ERAS is not specific for surgical subspecialties but applies general principles for the best patient response to physical and psychological impact of surgery (2).

During the last decade, a growing interest for ERAS practice has been observed with an increasing trend in scientific contribution and clinical practise. Most experiences of ERAS/fast track concern abdominal surgery and urology with very promising results (3-6). More recently, ERAS programme has been applied in particular patient subsets such as obesity and geriatric surgery. The available results, although they are preliminary, seem to support the ERAS directions to develop new strategies for patient management after surgery and indicate the intent to progressively adjust specific methodologies for a more and more appropriate patient-centred care (7). Some data also support ERAS/fast track for potential economic benefit coming from a systematically applied ERAS protocols (8).

ERAS Society has produced guidelines to facilitate the

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use of ERAS code but Thoracic Surgery subspecialties (cardiac, general thoracic, thoracic surgical oncology) and others are still spaces to be explored for possible application of ERAS. In fact, very limited experiences are available in literature with poor evidence (9).

For this reason, a prospective database of patients undergoing VATS pulmonary anatomical resections is created to possibly evaluate the applicability, the feasibility and the cost/effectiveness of ERAS standards in thoracic surgery using the VATS Group data collection and analytical methodology in order to highlight possible standardized procedure, clinical guidelines and economical aspects (10-13).

Summary of ERAS principles

ERAS/fast track includes different multidisciplinary approach to prepare, to support and to early discharge patients when they require a surgical procedure. The ERAS methodology lies on a strong connection between patients and caregivers including the surgeon with the goal to arrange and speed up the recovery process (14). Since this ideal process has already been developed, some steps of the ERAS route to recovery are already available (15).

Firstly, great importance is associated to the patient engagement. Patients must be educated and informed regarding their health condition and must be conscious of the therapeutic programme in order to be active part during the medical process and recovery. There are different tools to engage a patient for enhancing a fast recovery but evidence is limited. Likewise, the patient education is definitely a crucial aspect and it represents a momentous step in the ERAS process for a fast improvement after surgical manipulation (16). Additionally, emphasis is put on the nutritional and general condition especially regarding the comorbidities and their management in view of the surgical schedule (17). The traditional perioperative agenda is also discussed in recent literature with preliminary results supporting a shorter preoperative fasting time and early return to physical activity. For the ERAS Society, Anaesthesiology protocols should develop a more and more flexible management and, finally, the multidisciplinary approach must involve non-medical caregivers to help the progression of patients to the final discharge. Physiotherapists, nutritionists, behaviourists and other practitioners must be involved in the entire therapeutic management to create a single systematic care mission out of many specific serial inputs.

The Registry

Based on the VATS Group Registry Platform (12), a new section of the VATS Group Registry is created. A dedicated Commission with interest in implementing ERAS/fast track in Thoracic Surgery has developed the series of indicators according to ERAS Society standards. Based on the experiences of other surgical subspecialties and the available limited literature, the VATS Group dedicated Commission has developed possible ERAS protocols to be followed as instructions to manage patients undergoing VATS anatomical pulmonary resections.

The Registry allows for a prospective collection of data and possible analysis of effectiveness, feasibility and weakness of ERAS/fast track in pulmonary resection.

Admission is identified with a numerical code, which relates to the single patient and surgical Centre. There is no possibility to have the admission page and the patient identity page open at the same time according to privacy policy. The admission page also represents a page of synthesis of the enrolled patient (*Figure 1*).

The functional page, already present in the VATS Group Registry, has been edited in the ERAS platform. The Preoperative Patient Health Engagement scale (PHE-s) was added and represents a mandatory indicator to put in the patient's records otherwise the subject is automatically indicated as out of the protocol (*Figure 2*).

Perioperative management and nutritional support data need to be reported as part of the ERAS perioperative course of actions. Anemia and malnutrition are of crucial importance. Information regarding anemia and its management must be reported as well as preoperative fasting, postoperative nutrition resume, fluid balance and post-operative mobilization. Variables are expressed as a choice between two mutually exclusive possibilities (*Figure 3*).

Physiotherapy represents a momentous issue in the ERAS methodology, so a dedicated page is provided with a series of mandatory data that represent possible causes of ERAS protocol failure if not submitted to patients during the perioperative period. Information regarding the preoperative physiotherapy management, preparation to surgery, type of exercise and service provided as well as number and timing of physiotherapy sessions are the requested information to be put in the registry (*Figure 4*).

Anesthesiology protocols have been developed in many surgical specialties. Being so, to analyze different strategies for intraoperative management, especially concerning circulation, ventilation and drugs is considered promising for further critical analysis (*Figure 5*).

Figure 1 Admission page. A code is generated by the system and assigned to each patient, a summary of patient perioperative data is furnished and drop-out causes are signaled (arrows).

Figure 2 Preoperative PHE-s is uploaded with a survey model. *, means that the field is required, to be mandatory filled. PHE-s, Patient Health Engagement scale.

Figure 3 Perioperative management page. Information about anemia and nutritional status are presented in this page and information regarding treatment are required. *, means that the field is required, to be mandatory filled.

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Figure 4 Physiotherapy page. According to ERAS Society, physiotherapy must be provided during the entire perioperative period; the Registry asks for information regarding preoperative management, number and type of exercises, timing and duration of tutored sessions. *, means that the field is required, to be mandatory filled. ERAS, enhanced recovery after surgery.

Figure 5 Anesthesia page. A list of anesthesiology data is added, with emphasis on cardiovascular and respiratory conditions. *, means that the field is required, to be mandatory filled.

Figure 6 Surgical procedure page. Surgical protocol for ERAS VATS are required, despite information regarding of a possible second chest tube, ERAS protocol is considered accomplished if only one chest tube is placed for a limited duration up to 72 hours (arrows above). Moreover, information of pain relief techniques are required. Finally, intraoperative air leak must be treated with sealants and reported (arrows below). *, means that the field is required, to be mandatory filled. ERAS, enhanced recovery after surgery.

Surgery must be performed according to VATS criteria and several additional rules are proposed in the protocol. Only one chest tube with or without suction is admitted for the ERAS VATS surgery with a maximal time span of maximum 72 hours. Intraoperative air leaks must be reported and treated with sealants eventually (*Figure 6*).

Analgesia is a crucial issue for ERAS methodology. Mandatory acknowledgements are: scheduled pain evaluation, loco-regional analgesic technique to be performed and systemic analgesic adjuvant if necessary. A series of details regarding the techniques and timing of administration of analgesics are required (*Figure 7*).

At discharge, patient engagement and pain are the two subjective indicators asked. All the other information concerns the chest tube management and the day of discharge. Considering the objective of ERAS to enhance a fast track, the cut off day for a supposed successful ERAS VATS lobectomy is postoperative day 4 (*Figure 8*).

Figure 7 Analgesia data page. The focus of ERAS methodology in the analgesia management is the continuous control of analgesia and the flexibility and patient-centered protocol. ERAS patients must be evaluated at scheduled time, treated with loco-regional techniques with systemic adjuvants. *, means that the field is required, to be mandatory filled. ERAS, enhanced recovery after surgery.

Figure 8 Discharge data page. Patient engagement (PHE-s) is asked again (arrow above); pain condition is remarkable for a fine ERAS process to fast recovery and thus asked again (arrow). The discharge day is hypothetically put at day 4 as the limit for an acceptable ERAS/fast track route. Moreover, information on the chest drainage are requested to highlight the association between discharge from hospital and chest tube management (arrows below). *, means that the field is required, to be mandatory filled. PHE-s, Patient Health Engagement scale; ERAS, enhanced recovery after surgery.

Figure 9 Follow-up data page. A series of data regarding the 30 days after surgery are collected; ERAS items are: patient engagement (arrow above) with a new and final PHE-s, possible causes of readmission to hospital are here placed (arrow) and educational objectives accomplished (arrow below). All complications and events leading to enhanced recovery failure are reported here. *, means that the field is required, to be mandatory filled. PHE-s, Patient Health Engagement scale; ERAS, enhanced recovery after surgery.

The Registry is finally closed with the follow up pages. Already present in the original VATS Group database, data regarding facts happening during the first 30 days post-operatively are required. In this page, two items are added to the original database version according to ERAS Society guidelines: patients engagement and self-assessment of the goals accomplished during the recovery period. In case of return to hospital for events that require new admission for any kind of medical procedure, the patient is automatically marked as a patient in which the ERAS route has been fallacious (*Figure 9*).

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Footnote

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Enhanced recovery pathways in thoracic surgery: the Shanghai experience

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Abstract: The attempts to implement the enhanced recovery (ER) program based on multiple specialties to minimize errors and complications in addition to speeding up the patient's treatment and recovery as much as possible. In China mainland, there is no unified hospital system and there are large differences between hospitals' results and protocols. The patient length of stay rate at the Shanghai Pulmonary Hospital (very high-volume referral hospital) is 7 days and may be considered a very good result compared to international rates. Perhaps thanks to these results may be due to our belief in the importance of minimally invasive approaches, and their positive effects on the patients and conduct as routinely as possible, in addition to starting to build our ER protocols. The patient should be involved in this program since his first visit to the clinic until the day he left the hospital after undergoing the operation.

Keywords: Enhanced recovery (ER); thoracic surgery; postoperative complications; video-assisted thoracoscopic surgery

Introduction

Despite the significant recent advances in thoracic surgery and rapid transition from the era of traditional surgeries (open thoracotomy) to the era of minimally invasive surgery, R0 resection with lymph node dissection is still the optimal treatment for a patient with operable NSCLC (1,2). Lobectomy remains a major procedure and could be associated with a major morbidity and even mortality (3). Hence the importance of having a perioperative program based on multiple specialties to minimize errors and complications in addition to speeding up the patient's treatment and recovery as much as possible. Perhaps the first attempts to implement the enhanced

recovery (ER) program were in the early 1990s by Henrik Kehlet (4). Since then, an emphasis has been placed on this subject, given its importance and vitality. In the field of thoracic surgery, the main focus was on relieving patient's pain by providing the minimally invasive surgical techniques and development of therapeutic protocols controlling pain after surgery (5,6). The patient should be involved in this program since his first visit to the clinic until the day he left the hospital after undergoing the operation. The most important preoperative elements of this program are thoroughly medical advice, preparing the patient in terms of feeding optimization and smoking mitigation so that the patient in the most appropriate conditions for the surgery before being admitted to the hospital. During and after the

surgery, standard anesthetic and analgesic protocols, early mobilization, and fast-tracking chest drain management are the most important factors (7,8). In China mainland, because there is no unified hospital system and there are large differences between hospitals' results and protocols, there is no accurate information on the average length of hospital stay after undergoing a pulmonary resection. The patient length of stay rate at the Shanghai Pulmonary Hospital (very high-volume referral hospital) is 7 days and may be considered a very good result compared to international rates (9-11). Perhaps thanks to these results may be due to our belief in the importance of minimally invasive approaches, and their positive effects on the patients and conduct as routinely as possible, in addition to starting to build our ER protocols.

Preoperative outfit

ER depends on the patient is as good as the possible surgical condition. The goal of the patient's visit to the clinic is to give advice to him and give him some orientation in addition to starting work to review the state of health carefully and address the difficulties that may affect the journey of surgical treatment so that the patient can leave the hospital as soon as possible and with the best possible results. At this stage, the most important elements to pay attention to and approach are malnutrition, reducing smoking, treating anemia, and increasing physical activity, in addition to the importance of controlling blood pressure and diabetes. Patients suffering from chronic obstructive pulmonary disease (COPD) are treated by a pulmonologist so that they are given the ideal treatment of inhalers and bronchodilators; so that the lungs function in the best possible condition before the operation.

A nutritionist is consulted regarding patients with malnutrition and provides them with a diet advice appropriate to the patient's condition. The nutritionist follows the patient while in the hospital after the operation to follow up his condition and make sure that his nutritional status is well.

Although the period required to reap the benefit of stopping smoking prior to the operation of a pulmonary resection is unknown (12), the patient is asked not to smoke for at least 2 weeks before surgery. In cases of anemia (Hb less than 11 g/dL), the patient is referred to his or her physician to investigate the cause and correct the anemia before the procedure. In addition to its beneficial effects such as strengthening the patient's muscles and reducing

the psychological pressure, physical exercise may improve aerobic capacity and quality of life, and advised at all stages of treatment (13). We ask the patient to exercise as much as possible before the operation, at least climb the stairs several times a day and breathing exercises. From an anesthesia point of view, the anesthesiologist examines and evaluates patients with high risk of undergoing a pulmonary operation in the so-called initial preoperative assessment. The anesthesiologist identifies the circumstances that may lead to complications during and after the operation, the risk factors that can be adjusted preoperatively are directed and managed. In addition, the final preoperative assessment performed just before the operation (before the patient goes to the operating room). At this time, it is paramount to review the data from the initial evaluation and the results of the ordered tests before. There are two other determinants affecting the thoracic anesthesia: the difficult isolation of the lungs and the risk of saturation during lung ventilation (14).

Intraoperative management

When we discuss the ER system we must mention the advanced surgical techniques that are integral to this program. In our department, we believe in the importance of minimally invasive surgeries for the treatment of lung, mediastinal and chest wall pathologies because of its benefits in reducing pain and hurrying the recovery process after surgery significantly, in addition to reducing the complications after the operation (15-17). In recent years, the most advanced minimally invasive techniques have been adopted by most of the surgeons in our academy. More than 90% of the operations are performed by the VATS and most (even complex ones) are performed by intercostal, subxiphoid and subcostal uniportal VATS approaches (18-20). In addition to excellent results, these techniques have helped us to shorten the time and effort in pain management during and after the operation. Wherein we stopped using the epidural or paravertebral block during the surgery except in rare cases. And for the treatment of pain, we mainly rely on giving light intravenous (IV) or oral analgesics, this also of great benefit to further reduction of the rate of complications and accelerate the mobilization of the patient after surgery. Although restricted fluid administrations is required in some cases [e.g., post-pneumonectomy, congestive heart failure (CHF)], Acknowledgement of the importance of good hydration before surgery and its effect in facilitating fluid handling during the operation and minimizing the post-operative

Table 1 Analgesia protocol for postoperative patients

Time	Analgesia protocol
Day 0 (recovery room)	(I) To prescribe flurbiprofen axetil 50 mg IV after the patients transfer to post anesthesia care unit; (II) Not to use opioid antagonist or to reduce the dose if necessary; (III) Patients undergoing thoracotomy are given intercostal nerve block with 0.25% bupivacaine before closure of incision; (IV) For VATS patients, intravenous compound (sufentanil 50–100 μg + flurbiprofen axetil 100 mg + tropisetron) through patient-control intravenous analgesia (PCIA), and for thoracotomy patients, with the catheter placed in T7–T8, epidural analgesia (bupivacaine + fentanyl + tropisetron) by patient-control epidural analgesia (PCEA); (V) If patients are still in pain, to administer sufentanil 5–10 μg IV, and to pay attention to their breath; (VI) Reducing or avoiding flurbiprofen axetil in patients with gastrointestinal problem (e.g., ulcer), hepatic and renal dysfunction, hypertension, or patients undergoing pleurodesis
Day 0 (ICU)	(I) Continuing the PCA; (II) Patients could press the button by themselves to get 0.5 mL bolus every 15 minutes, if still painful; (III) While using PCEA, the catheter should be fixed on patients' back, and their breath and hemodynamics should be monitored; (IV) Administering metoclopramide 5–10 mg IV if patients was vomiting; (V) Anesthesia consultation should be required if patients are kept in pain
Day 1 (ward)	(I) Continuing the PCA; (II) Pausing PCA if patients have severe vomiting and/or used transdermal fentanyl (Duragesic) paste; (III) Administering intravenous metoclopramide 5–10 mg; (IV) Restarting PCA as vomiting stops
Day 2 (ward)	(I) Continuing the PCA; (II) While using PCEA, the adhesive tape should be changed to ensure the catheter would not slip out; (III) Prescribing oral oxycodone-acetaminophen (Tylox), 1 tablet (oxycodone hydrochloride 5 mg and acetaminophen 325 mg) PRN, more than 4 hours every time
Day 3 (ward)	(I) Stopping PCA; (II) Starting oral Tylox QD; (III) Reminding patients to visit pain clinic if they have any pain problems after discharge, especially to prevent chronic pain

IV, intravenous; VATS, video-assisted thoracoscopic surgery; PCA, patient-control analgesia; ICU, intensive care unit; QD, quaque die; PRN, pro re nata.

complications, we ask the patient to abstain from eating for 6 hours and from drinking for only 2 hours before entering the operating room. Ordinary patients are given 60–100 mL fluids per hour as a maintenance dose for 24 hours after the surgery. Prophylactic antibiotics are given within 30 minutes before the incision, and discontinued in the day after the surgery if there is no risk or evidence for infection. Premedications are not given prior to the operation in order to ensure the movement of the patient for as long as possible (until arrival to the door of the operating room). Venous access applied in the external jugular vein or peripherally and usually removed 1 day after the operation. Central venous pressure (CVP) lines are utilized only in specific cases when inotropic support or parental nutrition is anticipated. Urinary catheter applied in patients who are undergoing major surgeries and usually removed 1 day after the surgery if there are no obstacles.

Postoperative management

Controlling pain after thoracic surgery is a paramount factor for successful expeditious recovery, pain prevention, therefore, means preventing many complications after surgery. As mentioned earlier, the use of modern techniques in minimally invasive surgeries has enabled us to reduce the amount and doses of pain medications, in addition to significantly reducing the dependence on epidural and regional analgesia. Since there is an obvious difference in the level of pain between patients who undergoes thoracotomy compared to VATS patients, we have therefore implemented a protocol specific to each type of patients as shown in the table (*Table 1*). The patient is given his permanent medications after 48 hours of operation unless there is a health condition preventing this. We encourage the patient to move as soon as possible after surgery. Few

hours after the operation, the surgeons or nurses instruct the patient to move, to cough productively and how to use the spirometer or blow balloon. On the first day after surgery, doctor in charge visits the patient twice, then once a day or as needed. In most cases, we use only one chest drain. This leads to less pain after surgery and therefore less use of analgesics (21). The suction is not routinely used unless there is a need for it (a clinically important postoperative space), as this may help quicker removal of the tube and thus speed the patient out of the hospital (22-24). The use of the digital portable suction device is still uncommon in our department, but we are seeking to introduce this technology to serve our patients because of its benefits in promoting the postoperative mobilization of the patients, and facilitate decision-making to remove the chest drains without delay (25). The tube is removed when air leakage stops; the lung is expanded, and when the amount of fluid is less than 200 milliliters per day, provided that the fluid is not blood or chyle. Otherwise, the patient will discharge home with a chest drain in place (26,27). The discharge date and post-discharge arrangements should be verified and strengthened with the patient and his family on a daily basis. Acceptable status for the patient to be discharged from the hospital after making sure that his laboratory tests are fine is that there is no high temperature, moving freely without oxygen supplementation, able to expectorate without difficulties. In our department, the presence of the chest drain does not influence the time of discharge from the hospital unless it is suction dependent. The patient is provided with all the necessary instructions and how to act in the event of any complications expected after the process and is encouraged to communicate with the department if he has any queries.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Enhanced recovery pathways in thoracic surgery: the Quebec experience

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Background: Canada has a universal public health system where all resources must be allocated to optimize cost-effectiveness. Rapid diagnostic assessment programs (DAPs) and enhanced recovery protocols (ERPs) may improve timeliness of care and postoperative outcomes and thus reduce costs. The use of DAPs and ERPs in lung cancer patients who undergo lobectomy via video-assisted thoracoscopic surgery (VATS) is still controversial. This study measured the time between preoperative workup and treatment with a DAP and evaluated the impact of an ERP postoperatively in patients with early-stage non-small cell lung cancer (NSCLC) who received a VATS lobectomy.

Methods: We conducted a retrospective review of patients who underwent minimally invasive lobectomy for the primary treatment of lung cancer from January 2014 through May 2017 at our institution. Timelines of care were measured. Postoperatively, the duration of chest tube drainage, length of hospital stay, and incidence of complications were noted.

Results: During the study period, 646 patients underwent VATS lobectomy for stage I or II NSCLC; of these, 384 (59%) were assessed within the DAP. Using the DAP, the median time between the patient's first clinic visit and referral to surgery was 30.0 days [interquartile range (IQR), 21.0–40.0 days), and the median time between surgical consult and treatment was 29.0 days (IQR, 15.0–47.5 days). With the ERP, the median duration of chest drainage was 3.0 days (IQR, 2.0–6.0 days), and median hospital stay was 4.0 days (IQR, 3.0–7.0 days).

Conclusions: DAPs and ERPs have promising roles in thoracic surgical practice. A rapid DAP can expedite the care trajectory of patients with lung cancer and has allowed our institution to adhere to governmental standards for the management of lung cancer. ERPs are feasible to establish and can effectively improve clinical outcomes.

Keywords: Lung neoplasms; postoperative care; enhanced recovery; minimally invasive surgical procedures

Introduction

Canada's public health system is grounded in universal access to medical needs based on cost-effective quality care within federal standards. Prevention and treatment of chronic diseases, like lung cancer, is listed as a governmental focus. The timeliness of care of lung cancer patients is recognized as a quality-of-care indicator, and surgical candidates should be treated within 3 weeks of the surgical consultations. This standard meets international guidelines

for timely care of patients and is in agreement with the findings of studies using major lung cancer databases (1-3). Unfortunately, in 2014 only 50% of lung cancer patients in Canada met this ideal timeframe for the trajectory of diagnosis and treatment (4). In contrast to Canada's standard, the British Thoracic Society recommends a delay of no more than 8 weeks between the 1st consultation with a respiratory physician and surgical resection, and that the surgery should take place within 4 weeks of placement on a surgeon's waiting list (5).

Advances in imaging techniques and diagnostic strategies have allowed better patient staging and ultimately precise treatment strategies. Rapid diagnostic assessment programs (DAPs) have been implemented in multiple centers worldwide to coordinate timely diagnostic and staging investigations, timely referral to surgery or other specialties, and to maintain contact between the patient and the referring physician. We previously demonstrated that recommended targets for patient wait times in the investigation and treatment of lung cancer can be achieved within a DAP at our center (6).

Thoracic surgery has also evolved. Minimally invasive surgery is now considered the standard approach for early-stage lung cancer patients with several proven benefits such as fewer postoperative complications, shorter hospital stays, and shorter durations of chest tube drainage (7). In fact, the feasibility, safety, effectiveness, and cost-effectiveness of minimally invasive lobectomy have all been well demonstrated as compared with open surgery (8).

Postoperative enhanced recovery protocols (ERPs) focus on improving surgical outcomes through standardized postoperative fast-track protocols, and were first described in colorectal surgery, urology, and gynecology (9-13). Surgical goals in patients with lung cancer should include a short trajectory time between diagnosis and surgery, a short hospital stay, and expedited return to daily activities. Thoracic surgeons adopted ERPs for the management of lung cancer patients treated surgically only recently (14,15). The aims of this study were to measure the timeliness of care with a standardized DAP in patients with early-stage non-small cell lung cancer (NSCLC) and to evaluate the impact of an ERP in these patients.

Methods

Patients

We conducted a retrospective review of a prospectively maintained departmental database of all lung cancer surgeries performed at the Institut Universitaire de Cardiologie et de Pneumologie de Quebec (IUCPQ), a tertiary-referral and university-affiliated hospital. The database was queried for all lobectomies performed between January 2014 and May 2017. The thoracic surgery division has four board-certified thoracic surgeons, and all patients with early-stage lung cancer who were fit for surgery were approached by VATS. The Ethics Committee approved this study and waived the requirement for informed consent.

Only patients with clinical stage I or II NSCLC, according to the American Joint Committee on Cancer (AJCC) 7th edition Tumor Node Metastasis (TNM) classification (16), who were completely staged with computed tomography (CT) and positron emission tomography (PET) scanning and underwent VATS lobectomy were included in the final analysis. Invasive mediastinal staging was performed when recommended, according to the European Society of Thoracic Surgeons (ESTS) guidelines (17). Not all patients had brain imaging as part of their diagnostic staging. Video-assisted thoracoscopic surgery (VATS) lobectomy could be performed either by a uniportal or multiportal approach. Two groups of patients were identified: those who underwent a complete oncologic and clinical work-up in our institution with our standardized DAP and those who were diagnosed outside the institution and directly referred to the thoracic surgery service. The timelines were not analyzed in the latter group.

DAP

In September 2008, an institutional rapid DAP called "Green Files" was established as the routine trajectory for all lung cancer patients cared for at the IUCPQ. The objective was to expedite each patient's care from diagnosis to treatment. In this program, once a green file is opened, each case is analyzed by an oncology nurse navigator together with a respirologist, and all clinical tests and lung cancer staging exams are ordered. Pulmonary function tests, bronchoscopy, endobronchial ultrasound (EBUS), chest CT-scan, PET scan and brain imaging are performed within 2 to 3 weeks. Once the workup is completed, patients have a respirology consultation, and the most appropriate treatment is determined. Surgical candidates are promptly referred to the thoracic surgery clinic. When surgery is not an option because of clinical staging or comorbidities, patients have priority medical consultations with other

specialists.

Patient education is a priority, so we dedicate a great amount of time to inform our patients about their disease, the planned surgical procedure, and the recovery period. At the thoracic surgery clinic, patients receive all necessary information about the planned surgery, and the consent form is signed. Subsequently, they meet with a surgical nurse for surgical education. All patients receive a booklet with detailed information about the surgery and the anticipated postoperative care. Patients are also referred for preoperative smoking cessation counseling and a physical-training program when needed. For surgery, most patients have a same-day admission, with exception of patients coming from distant regions of the province.

In this study, the timelines of care of patients with lung cancer within the DAP were examined for 3 intervals. The first one was the interval between the moment that the green file was opened until all lung cancer staging and clinical tests were performed, and patient was referred for surgery after discussion with the respirologist. The second interval was the time between the referral to the thoracic surgery department and the consult with the surgeon, and the last interval was from the surgical consult to the date of surgery.

Surgical management

VATS lobectomy was performed under general anesthesia with single-lung ventilation. The type of VATS technique was at the discretion of the surgeon; either a multiportal or uniportal approach could be used. Once the pleural space was entered, a thoracoscopic exploration was performed to confirm resectability. For lobectomy, all vascular structures were dissected separately, followed by the bronchus. Hilar and mediastinal lymphadenectomy or sampling were routinely performed. The majority of the patients did not have an epidural catheter, so they benefited from preemptive analgesia and intercostal nerve block with Marcaine (0.25%) under direct visualization. At the end of each procedure, a 24-French chest tube was inserted for drainage.

Postoperative management and discharge

Most patients recovered in a step-down unit, though infrequently recovery in the intensive care unit was preferred. The postoperative care was via a standardized ERP for all patients (*Table 1*). Under the ERP, chest tube suction was not routinely used. Lower limb compression devices were removed on postoperative day 1. The patients

were mobilized 4 hours postoperatively to a chair and were encouraged to walk under supervision on the evening of the procedure. The physiotherapy department ensured that patients practiced respiratory exercises regularly and had daily walks. Family members were encouraged to help mobilize the patient. A fluid diet was started on the evening of the surgery and was progressed to a normal diet on postoperative day 1 after intravenous fluid administration was ceased.

Medications used for pain control varied according to the surgeons' preferences. In general, a combination of oral acetaminophen or nonsteroidal anti-inflammatory drugs with or without a patient-controlled analgesia (PCA) pump with hydromorphone was used. Only a minority of patients had an epidural catheter. Anesthesiologists followed all patients with epidural analgesia or PCA to optimize pain control (18-20).

Discharge

Patients were informed of the discharge 24 to 48 hours in advance. The discharge could be on the same day of chest tube removal but was more frequently the next morning. Because we are a tertiary referral lung cancer center, our patients reside throughout the province of Quebec, and discharge was occasionally delayed due to social issues. Patients were well informed before departure, and the booklet with information about postoperative care was reviewed. The first postoperative visit was scheduled for 2 weeks after discharge.

Data extraction

We searched the patients' medical records for the following general information: age, sex, tumor histology and tumor clinical and pathological stage according to the AJCC 7th edition TNM classification for malignant tumors. For patients in the DAP, we collected the date that the green file was opened, the date the patient was considered a surgical candidate and referred to thoracic surgery, the date of the first consultation in the thoracic surgery clinic, and the date of the surgery. Also, all postoperative data related to the ERP were collected including postoperative complications, the duration of chest tube drainage, the length of hospital stay and mortality outcomes.

Statistical analysis

Median and interquartile ranges (IQR) are used to

Table 1 Enhanced recovery protocol strategies

Preoperative strategies

   Preoperative visit, evaluation, and investigations with accelerated DAP

   Patient education, smoking cessation, preoperative workout plan, and explanation of the ERP

   Same-day admission

Perioperative strategies

   Antibiotic and venous thromboembolism prophylaxis

   Regional anesthesia as needed

   Goal-directed fluid therapy

   Minimally invasive surgery (VATS)

   Chest drainage

Postoperative strategies

   Avoidance of opiates

   Avoidance of intravenous fluid overloading

   Early ambulation, feeding, and physiotherapy

   Rapid-recovery-directed nursing

   Early removal of chest tubes

   Postoperative education

   Booklet about postoperative care

   Rapid, elective, clinical reassessment

DAP, diagnostic assessment program; ERP, enhanced recovery protocol; VATS, video-assisted thoracoscopic surgery.

summarize patient characteristics and time intervals. For each patient, the number of days from opening the green file for the lung cancer investigation to surgical resection was identified. Categorical variables are reported as n (%). Continuous variables are expressed as a median (IQR, 25th to 75th percentile) depending on variable distribution. Analyses were conducted using the statistical package SAS, version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

From January 2014 to May 2017, 838 lobectomies were performed in our center. Of these 838 lobectomies, 646 were performed for the primary treatment of early-stage NSCLC (*Figure 1*) all by VATS. Median age of the 646 (77%) patients who underwent VATS lobectomy was 66 years (IQR, 60–72 years). Other demographics are

presented in *Table 2*.

Out of the 646 VATS lobectomies, 384 patients (59%) were diagnosed and treated at the IUCPQ using our DAP. For these patients, the median time from opening the green file until surgery was 67.0 days (IQR, 50.0–88.0 days). Median time from opening the green file until surgical referral was 30.0 days (IQR, 21.0–40.0 days), median time from referral to surgical consult was 6.0 days (IQR, 2.0–11.5 days), and median time from surgical consult to surgery was 29.0 days (IQR, 15.0–47.5 days).

The postoperative care of all 646 patients who underwent VATS lobectomy for clinical stage I and II NSCLC, was under the guidance of our ERP. Perioperatively, median bleeding was 100 mL (IQR, 40–150 mL) and median operative time was 150 minutes (IQR, 123–190 minutes). The median hospital stay was 4.0 days (IQR, 3.0–7.0 days). The median duration of chest tube drainage was 3.0 days (IQR, 2.0–6.0 days). Postoperative complications were classified into pleural, cardiac, respiratory, prolonged air leak, neurogenic, and other complications (*Table 3*). Thirty patients (4.6%) had pleural complications, most frequently high pleural fluid output for 5 days or more. Cardiac complications, such as arrhythmia, occurred in 83 patients (12.8%). A prolonged air leak (classified as 5 days or more) was the most common complication and occurred in 144 patients (22.3%). There were three deaths within 30 days of VATS (0.5%). One patient died from septic shock. One died a sudden death after hospital discharge, and one patient who had pulmonary fibrosis died of acute respiratory failure.

Discussion

At our institution, we routinely apply a DAP and an ERP when caring for patients with lung cancer. In this study, we measured the time between preoperative workup with a DAP and treatment with VATS lobectomy in patients with early-stage NSCLC. We also evaluated the impact of an ERP postoperatively in these patients after VATS lobectomy. The rapid DAP expedited the care trajectory of our patients; however, Canadian standards for the care trajectory of patients with lung cancer were not met. Indeed, we had a median delay between acceptance on the surgical waiting list and surgery of 29 days, longer than the 21 days recommended by the Canadian Cancer Society and the Quebec Council Against Cancer (Conseil québécois de lutte contre le cancer) (2,4). A number of factors may explain this delay including the referral and management of patients
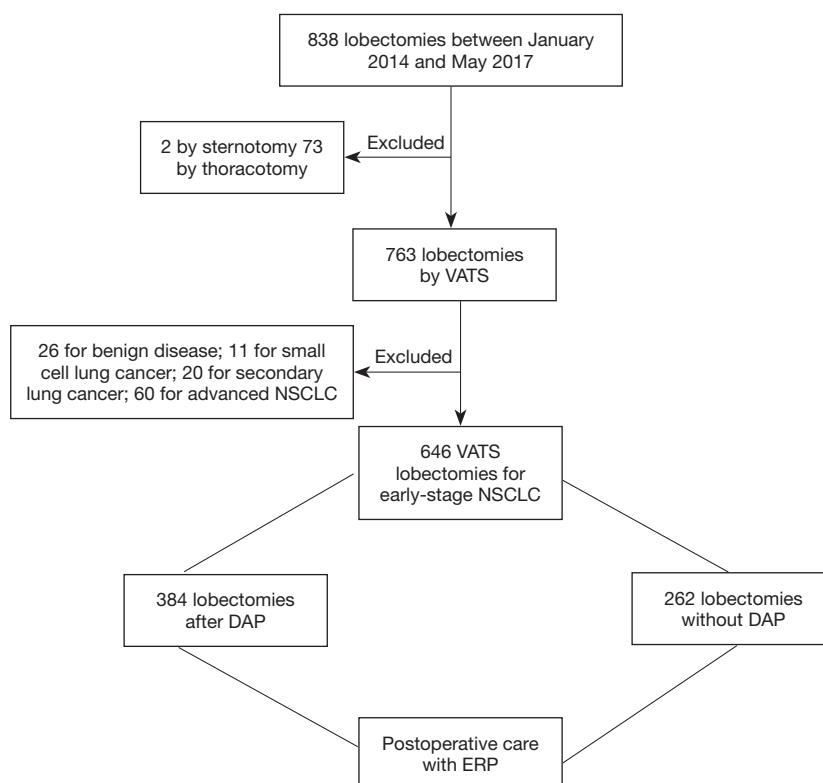
Figure 1 Flow chart of patients included and excluded from the study. DAP, diagnostic assessment program; ERP, enhanced recovery protocol; NSCLC, non-small cell lung cancer; VATS, video-assisted thoracoscopic surgery.

Table 2 Patient characteristics

Characteristics	Patients (N=646), n [%]
Sex	
Male	264 [41]
Female	382 [59]
Histology	
Adenocarcinoma	475 [74]
Squamous cell	125 [19]
Others	46 [7]
Pathologic stage[1]	
IA	285 [44]
IB	181 [28]
IIA	90 [14]
IIB	52 [8]
IIIA	36 [6]
IIIB	0 [0]
IV	2 [0]

[1], the 7th edition AJCC TNM classification was used.

coming from remote regions of the province, the evolving difficulty of lung cancer cases, and the complexity of the battery of tests that need to be performed before deciding an appropriate course of treatment. When compared with the standards put forth by the British Thoracic Society (5), our waiting time from referral to surgery was comparable to their recommendation of a maximum of 4 weeks.

Patients with a diagnosis of early-stage NSCLC should be cared for with efficiency through diagnosis, staging, and treatment. Programs and strategies that reduce treatment delays lead to higher rates of surgical resection (21). Many clinicians have raised concerns that delaying surgical intervention might worsen survival, but the literature has not confirmed that there is a direct correlation between a short interval from lung cancer diagnosis to surgical treatment and survival. In 2002, Aragoneses and colleagues presented a retrospective analysis of 1,082 patients with early-stage NSCLC treated with surgical resection. The median therapeutic delay between diagnosis and surgical treatment was 35 days, and median survival was 32 months. In a multivariable analysis, they did not observe a

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Table 3 Postoperative complications

Complications[1]	Patients (N=646), n (%)
Pleural	30 (4.6)
Chylothorax	8 (1.2)
Hemothorax	6 (0.9)
Empyema	3 (0.5)
High pleural effusion output (≥5 days)	13 (2.0)
Cardiac	83 (12.8)
Arrhythmia	79 (12.2)
Ischemic	4 (0.6)
Shock	3 (0.5)
Respiratory	75 (11.6)
Acute respiratory distress syndrome	6 (0.9)
Respiratory tract infection	37 (5.7)
Atelectasis	7 (1.1)
Pulmonary edema	6 (0.9)
Pulmonary hypertension	1 (0.2)
Pulmonary fibrosis exacerbation	1 (0.2)
Respiratory failure	23 (3.6)
Bronchopleural fistula	3 (0.5)
Pulmonary infarction	1 (0.2)
Prolonged air leak (≥ 5 days)	144 (22.3)
Neurogenic (Recurrent nerve palsy)	10 (1.5)
Other[2]	32 (5.0)

[1], patients could have more than one complication; [2], other complications included acute renal failure, 15 (2.3%) patients; urinary tract infection, 7 (1.1%) patients; digestive, 2 (0.3%) patients; peritonitis, 1 (0.2%) patient; wound infection, 1 (0.2%) patient; cerebrospinal fluid leak, 3 (0.5%) patients; other vascular complications, 3 (0.5%) patients.

correlation between therapeutic delay and overall survival (22). In 2003, Quarterman and colleagues studied 84 patients with resected stage I or II NSCLC (23). Median interval between presentation and surgical treatment was 82 days. They were unable to demonstrate a negative effect of longer preoperative delays on overall survival (P=0.54) but argued that their confidence interval (CI) was broad and that larger sample size was necessary to reach definitive conclusions. Our median delay between diagnosis and surgical management was 67 vs. 82 days in Quaterman's

study. Conversely, Yang and colleagues (3) reviewed 4,984 patients who underwent lobectomy for stage IA squamous cell carcinoma using the National Cancer Database (2006–2011). In these patients, 5-year overall survival was 58.3% (95% CI, 56.3–60.2%). Patients who had surgery 38 days or more after diagnosis had significantly worse 5-year overall survival than patients who had surgery earlier [hazard ratio (HR), 1.13; 95% CI, 1.02–1.25; P=0.02]. Further analysis is necessary to examine 5-year overall survival in our cohort and compare it with Yang's results.

Growing experience with ERPs for thoracic surgery patients confirm the role of pain control strategies and standardized postoperative care (24). ERPs typically focus on early mobilization, early chest-tube-drainage removal, and planned discharge. Scarci and colleagues recently published a retrospective study comparing 154 patients treated with an ERP and 171 patients treated in the year before introducing the ERP (14). The patients treated using the ERP showed a significantly higher number of procedures done by VATS (32.9% VATS vs. 9.4% thoracotomy, P=0.0001), significantly shorter postoperative hospital stays (5.2 vs. 11.7 days, P<0.0001), and higher patient satisfaction. We observed short postoperative hospital stays and an encouraging profile of postoperative complications after VATS lobectomy using our ERP.

Based on our experience and the evidence discussed above, rapidly assessing and staging patients with potentially resectable lung cancer may reduce delays prior to surgical treatment. Through minimally invasive techniques for the resection and the standard application of ERPs after surgery, lung cancer patients may benefit from fewer postoperative complications and overall superior outcomes. Even though there is not a global, organized system to diagnose and stage lung cancer and ERPs are still not widely used, our group strongly believes that this should and will become the standard. However, further analyses are necessary to evaluate if these approaches improve survival in surgical patients.

Our study has several limitations. The retrospective and descriptive qualities of the study do not reflect any comparison between patients in an ERP and those who are not. It is also a single-center study, and conclusions of our practice cannot be generalized to all centers practicing thoracic surgery. However, this study is, to our knowledge, the largest single-institution report combining a rapid DAP, minimally invasive surgical techniques, and an enhanced recovery postoperative program.

Conclusions

In summary, ERPs should be considered the standard of care and are being applied at an increasing number of academic and non-academic institutions in growing number of surgical specialties. Thoracic surgery is following this trend, and studies detailing these experiences are getting published. Our DAP and ERP at the IUCPQ seem to present good results with acceptable diagnosis-to-treatment waiting times and postoperative hospital length of stay. Comparison between the current fast-track pathways and previous conservative management strategies at our institution has not yet been done. Cost-effectiveness and postoperative patient satisfaction also warrant further investigations.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The Ethics Committee of XXXXX approved this study (No. XXXX) and waived the requirement for informed consent.

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