Review Article

Enhanced recovery after thoracic anesthesia

ABSTRACT

In recent years, the concept of "Perioperative Medicine" has been evolved to a more concrete and sophisticated approach called "Enhanced Recovery After Surgery" (ERAS). ERAS has been first introduced in colorectal surgery by a dedicated leading ERAS® society, ERAS-criteria has been subsequently extended into several types of surgery, including thoracic surgery.

Anesthesiology has always been one of the most important components of the multidisciplinary perioperative approaches, which is also valid for ERAS. There are several guidelines published on the enhanced recovery after thoracic surgery (ERATS). This article focuses on the "official" ERATS protocols of a joint consensus of two different societies. Regarding thoracic anesthesia, there are some challenges to be dealt with. The first challenge, although there is a large number of studies published on thoracic anesthesia, only a very few of them have studied the overall outcome and quality of recovery; and only few of them were powered enough to provide sufficient evidence. This has led to the fact that some components of the protocol are debatable. The second challenge, the adherence to individual elements and the overall compliance are poorly reported and also hard to apply even in the best organized centers. This article explains and discusses the debatable viewpoints on the elements of the ERATS protocol published in 2019 aiming to achieve a list for the future steps required for a more effective and evidence-based ERATS protocol.

Key words: Enhanced recovery; perioperative medicine; thoracic anesthesia

Introduction

The "Enhanced Recovery After Surgery" (ERAS) program, a multimodal, evidence-based approach, combining various recommended perioperative care measures from the early initial referral of the patient until discharge from the hospital, has been first introduced in 2005.[1] During the last decade, several ERAS programs including international guidelines for various surgical specialties have been published.[2-4] The ERAS society, a leading dedicated society, is not only publishing the recommendations on ERAS but also implementing the ERAS programs in different centers. In several studies, the ERAS programs are effective in reducing hospital length of stay, overall costs of healthcare, and incidences of postoperative complication.[5-7] These programs have achieved a very important new step to support the philosophy of perioperative medicine.

For most surgical cases, anesthesiologists are responsible not only during the "intraoperative" stage but also during the entire "perioperative" period. In the multidisciplinary context of "perioperative medicine," anesthesiology is one of the most important key components to find solutions for the different challenges from the practical, financial,

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and scientific points of view. "Thoracic anesthesiology" is qualified to stand as the primary discipline within anesthesiology specialties to take responsibility in developing "perioperative medicine." That is because the thoracic anesthetists in many centers worldwide are in the charge for the organization of perioperative care plans, for example, preoperative evaluation and preparation, postoperative care including postoperative intensive care, postoperative pain management, etc. This fact would explain the crucial roles of "thoracic anesthetists" in "Enhanced Recovery After Thoracic Surgery" (ERATS).

The notable success of the ERAS program in colorectal surgery cannot be only explained with the long experience in this area, but also a higher adherence to its components.[8] Regarding thoracic surgery, there are different comparable ERATS protocols (with similar, but not the same recommendations) developed from different centers in different countries.[9-17] The Enhanced Recovery After Surgery (ERAS®) Society and the European Society of Thoracic Surgeons (ESTS) have subsequently developed an international "formal" consensus on ERATS.[15]

This article aims to focus on discussing the debatable viewpoints on the different elements of the ERAS®–ESTS recommendations for ERATS.

ERATS Recommendations

The authors reviewed nine different ERAS protocols[9-17] in addition to a review article which compared five protocols of them.[18] We have considered discussing the joint consensus of the ERAS–ESTS as the main reference,[15] as this is the most recent "official" related publication. The joint consensus of the ERAS–ESTS on ERATS including the recommendations on the 45 enhanced recovery-related items covering topics related to preadmission, admission, intraoperative care, and postoperative care and their "evidence level" and "recommendation grade" are shown in Table 1.[15]

In general, all articles have similar suggestions; but looking into details, one can easily recognize the differences that can affect the practical approach.[18] In this manner, it should be underlined that the joint-consensus article is also the most elaborated reporting one but also has its limitations.

Here, the authors summarize the general recommendations; but we will not compare each of them with the similar elements of the different protocols to avoid unnecessary confusion. The authors will try to emphasize the "thoracic anesthesiologist's" point of view. The limitations, challenges, and probable future aspects have been discussed in the "Discussion Section."

1. Preoperative education should be extended to cover also the anesthetic procedures, such as preoperative approaches for postoperative analgesia, eventual postoperative mechanical ventilation, early mobilization, practicing respiratory exercises, etc.
2. Perioperative nutrition and preoperative fasting: There may be no more a place for nil per os "NPO." This approach is also appropriate for judicious intraoperative fluid management. Additionally, avoiding further weight loss and preoperative carbohydrate loading should be considered.
3. Smoking cessation and management of alcohol dependence: Should be considered even in case of having a short time until surgery, despite a longer cessation time (4 weeks or longer) might be necessary to have an effective impact.
4. Anemia management: Importantly, future research is required to test the efficacy of multidisciplinary perioperative "patient blood management" and "enhanced recovery after surgery" (ERAS).[19] A rational pathway is needed to find a midway between the challenge of "avoiding or correcting anemia, but also avoiding blood transfusion."
5. Pulmonary rehabilitation and "prehabilitation" are also important future aspects for perioperative anesthesia, but it requires full institutional support to generalize them.
6. Premedication: There is no more role for preoperative administration of benzodiazepines.
7. Venous thromboembolism prophylaxis and antibiotic prophylaxis: Appropriate timing and algorithms should be considered, additionally administration of prophylactic antibiotic should be administered within 60 min of the start of surgery, but before the skin incision. Therefore, the differences between the efficacy and safety of the different institutional protocols and practice should be studied.
8. Preventing intraoperative hypothermia: Intraoperative monitoring of body temperature is one of the five "obligatory" standard monitoring during anesthesia.
9. Anesthetic protocol: "Protective one-lung ventilation" is another ongoing discussion of the discipline of thoracic anesthesia. The combined use of general and regional anesthesia has its advantages and disadvantages. There is a debate about the superiority of using intravenous or inhalational anesthetics for thoracic surgery. In this element, there are differences between the different institutional protocols that can affect the practical approach.

Table 1: The elements of the recent ERATS guideline of ERAS®–ESTS (Ref. [15])

Recommendations	Evidence level	Recommendation grade
Preoperative phase		
Preadmission information, education, and counseling		
Patients should routinely receive dedicated preoperative counseling	Low	Strong
Perioperative nutrition		
Patients should be screened preoperatively for nutritional status and weight loss	High	Strong
Oral nutritional supplements should be given to malnourished patients	Moderate	Strong
Immune-enhancing nutrition may have a role in the malnourished patient postoperatively	Low	Weak
Smoking cessation		
Smoking should be stopped at least 4 weeks before surgery	High	Strong
Alcohol dependency management		
Alcohol consumption (in alcohol abusers) should be avoided for at least 4 weeks before surgery	Moderate	Strong
Anemia management		
Anemia should be identified, investigated, and corrected preoperatively	High	Strong
Pulmonary rehabilitation and prehabilitation		
Prehabilitation should be considered for patients with borderline lung function or exercise capacity	Low	Strong
Admission		
Preoperative fasting and carbohydrate treatment		
Clear fluids should be allowed up until 2 h before the induction of anesthesia and solids until 6 h before induction of anesthesia	High	Strong
Oral carbohydrate loading reduces postoperative insulin resistance and should be used routinely	Low	Strong
Preanesthetic medication		
Routine administration of sedatives to reduce anxiety preoperatively should be avoided	Moderate	Strong
Perioperative phase		
Venous thromboembolism prophylaxis		
Patients undergoing major lung resection should be treated with pharmacological and mechanical VTE prophylaxis	Moderate	Strong
Patients at high risk of VTE may be considered for extended prophylaxis with LMWH for up to 4 weeks	Low	Weak
Antibiotic prophylaxis and skin preparation		
Routine intravenous antibiotics should be administered within 60 min of, but prior to, the skin incision	High	Strong
Hair clipping is recommended if hair removal is required	High	Strong
Chlorhexidine–alcohol is preferred to povidone–iodine solution for skin preparation	High	Strong
Preventing intraoperative hypothermia		
Maintenance of normothermia with convective active warming devices should be used perioperatively	High	Strong
Continuous measurement of core temperature for efficacy and compliance is recommended	High	Strong
Standard anesthetic protocol		
Lung-protective strategies should be used during one-lung ventilation	Moderate	Strong
A combination of regional and general anesthetic techniques should be used	Low	Strong
Short-acting volatile or intravenous anesthetics, or their combination, are equivalent choices	Low	Strong
PONV control		
Nonpharmacological measures to decrease the baseline risk of PONV should be used in all patients	High	Strong
A multimodal pharmacological approach for PONV prophylaxis is indicated in patients at moderate risk or high risk	Moderate	Strong
Regional anesthesia and pain relief		
Regional anesthesia is recommended with the aim of reducing postoperative opioid use. Paravertebral blockade provides equivalent analgesia to epidural anesthesia	High	Strong
A combination of acetaminophen and NSAIDs should be administered regularly to all patients unless contraindications exist	High	Strong
Ketamine should be considered for patients with preexisting chronic pain	Moderate	Strong
Dexamethasone may be administered to prevent PONV and reduce pain	Low	Strong
Perioperative fluid management		
Very restrictive or liberal fluid regimes should be avoided in favor of euvolemia	Moderate	Strong
Balanced crystalloids are the intravenous fluid of choice and are preferred to 0.9% saline	High	Strong
Intravenous fluids should be discontinued as soon as possible and replaced with oral fluids and diet	Moderate	Strong

Contd...

Table 1: Contd...

Recommendations	Evidence level	Recommendation grade
Atrial fibrillation prevention		
Patients taking β-blockers preoperatively should continue to take them in the postoperative period	High	Strong
Magnesium supplementation may be considered in magnesium deplete patients	Low	Weak
It is reasonable to administer diltiazem preoperatively or amiodarone postoperatively for patients at risk	Moderate	Weak
Surgical technique: thoracotomy		
If a thoracotomy is required, a muscle-sparing technique should be performed	Moderate	Strong
Intercostal muscle- and nerve-sparing techniques are recommended	Moderate	Strong
Reapproximation of the ribs during thoracotomy closure should spare the inferior intercostal nerve	Moderate	Strong
Surgical technique: minimally invasive surgery		
A VATS approach for lung resection is recommended for early-stage lung cancer	High	Strong
Postoperative phase		
Chest drain management		
The routine application of external suction should be avoided	Low	Strong
Digital drainage systems reduce variability in decision-making and should be used	Low	Strong
Chest tubes should be removed even if the daily serous effusion is of high volume (up to 450 ml/24 h)	Moderate	Strong
A single tube should be used instead of 2 after anatomical lung resection	Moderate	Strong
Urinary drainage		
In patients with normal preoperative renal function, a transurethral catheter should not be routinely placed for the sole purpose of monitoring urine output	Moderate	Strong
It is reasonable to place a transurethral catheter in patients with thoracic epidural anesthesia	Low	Strong
Early mobilization and adjuncts to physiotherapy		
Patients should be mobilized within 24 h of surgery	Low	Strong
Prophylactic minitracheostomy use may be considered in certain high-risk patients	Low	Weak

ERAS: Enhanced Recovery After Surgery; ESTS: European Society of Thoracic Surgeons; LMWH: low-molecular-weight heparin; NSAIDs: nonsteroidal anti-inflammatory drugs; PONV: postoperative nausea and vomiting; VATS: video-assisted thoracoscopic surgery; VTE: venous thromboembolism

10. Postoperative nausea and vomiting (PONV) control is an important topic, which is sometimes underestimated.
11. Postoperative pain management is another large topic for discussion. Epidural analgesia is still the gold standard but it loses its popularity. The use of thoracic epidural analgesia (TEA) might be limited, if any, to open thoracotomies. There are extending roles for the different analgesia techniques, including truncal blocks, which therefore represent a rich area for future research. An important suggestion is to "avoid the use of opioids," which is also crucial for PONV control. Additionally, the use of dexamethasone is recommended in many protocols because of its beneficial effects on both of prophylaxis against PONV and improved quality of pain control.
12. Perioperative fluid management: There is no consensus on the optimum strategy for perioperative fluid therapy among the different protocols. The recommendations in the ERAS–ESTS joint consensus on ERATS include the most rational strategy in terms of avoidance of both of the "very restrictive or liberal fluid regimens" in favor of euvolemia. Inconsistently some of the other ERATS protocols suggested considering very restrictive fluid therapy strategies. In addition to the volume of fluid therapy, the type of fluid therapy, namely, using balanced crystalloids instead of saline, and timing of administering the intravenous fluid volumes are topics to be further examined.
13. Atrial fibrillation prevention: Should be considered during planning for the appropriate anesthesia techniques and medicaments.
14. Surgical technique: The surgical approach, thoracoscopy rather than open thoracotomy, and muscle sparing, and intercostal nerve sparing in case of the latter are important elements to be considered for ERATS.
15. Chest drain management: It is another big issue, especially for lung resection surgery, but also for anesthesia. There is an elucidated relationship between the use of chest drain and intensity of pain management and early mobilization.
16. Urinary drainage should be avoided as much as possible. However, that recommendation should be carefully interpreted in patients receiving TEA because of the risks for changes in urinary dynamics.
17. Early mobilization: Depends on several independent factors including effective prehabilitation, nutrition support, and pain management, avoiding or minimizing the use of opioids and early removal of the chest drain.

Here, it should be again noted that these recommendations above are just a summary of the joint-consensus (ERAS–ESTS)

protocols [Table 1] with a noncomprehensive comparison to other protocols, emphasizing also the anesthesiological point of view.

Discussion

The philosophy of ERATS is based on optimizing care during all stages of the perioperative period, namely, preoperative evaluation and preparation, intraoperative management, and postoperative care focusing on "enhanced" recovery and decreases the incidence of postoperative complications. In this section, the authors discuss some of the components of the ERAS–ESTS consensus on the ERATS, with raising new questions for further investigations.

First, most importantly, we have to acknowledge that ERAS; particulary ERATS has an appealing philosophy that should motivate the clinicians and academicians to change their paradigms and horizons and divert our point of views towards better perioperative care plans. There are thousands of studies in thoracic anesthesia and thoracic surgery; the majority of them were not concerned about studying the more important general clinical outcomes. The future designed studies and developed "standard operating procedures" should aim at the "more enhanced" recovery outcomes.

However, the fact that most of these thousands of studies have not focused on the recovery has also led to an important limitation of generalizability of the ERATS consensus. It is also claimed by the authors of ERAS–ESTS consensus on ERATS that some of the components of the recommendations are strongly recommended despite a low quality of evidence.[15,20] Some recommendations such as alcohol abuse management, preoperative anemia management, carbohydrate treatment, VTE prophylaxis, and early enteral feeding are based on data extrapolated from the other specialties.[15] This does not decrease the scientific value and philosophical importance of these recommendations but should be reconsidered as a motivation for both the academicians and clinicians to improve the ERATS protocols. We might quote the title "ERATS is still in its infancy" which has been cited by some of the authors of the protocols to express the current position of ERATS.[20,21] This also can partly explain why there have been different ERATS protocols reported by the different centers including some different suggestions.

Second, an important issue is the "compliance" of the practitioners with the components of the ERATS protocol. In a recent study, Forster *et al.* have shown that high compliance with ERATS was associated with better postoperative outcomes in patients undergoing VATS resections.[22] Interestingly, the results of this study showed that the overall compliance was 76% and patients met the criteria for "high compliance" experienced fewer complications than those with "low compliance" (18% vs. 48%). This study was performed in a very experienced center with previously described ERAS protocols in Switzerland. It can be assumed that these ratios would be lower in the less experienced centers. Therefore, by determination of such protocols, a rational, pragmatic balance between obligatory suggestions and "simplicity" should be kept: "The more complex a protocol, the higher the difficulties with compliance."[23]

Third, another interesting result of the aforementioned study was that the "preoperative education" was one of the elements with the least compliance rate (53%).[22] This item appears to be one of the well-known, most obvious and probably easiest-to-apply recommendations. The benefits of preoperative counseling are well known since 1960s[24] have been shown in most studies, especially leading to a more sufficient postoperative pain control, patient satisfaction, enhanced recovery, and earlier discharge from the hospital. Moreover, contrary to some other elements, this element is one of the least controversial ones; and not at least, one of the easiest to apply suggestions. This finding again shows that the compliance to protocols is a complicated issue, and affected by the patient, clinical approach, and organizational conditions.

Fourth, evaluating the effects and benefits of ERATS, a classic "chicken-egg question" should be also considered. As a concrete example, the majority of the ERATS protocols agree on early removal of chest tubes even in case of a high volume of daily serous pleural effusion up to 450 ml/24 h.[15] That is still a traditional and historical challenge of thoracic surgery. From this point of view, the implication of the clear and enthusiastic recommendation of ERATS on chest tube management can potentially challenge the older paradigms. The adherence to ERAS elements is associated with a more successful postoperative outcome, and this is one of the more obvious components that is associated with a reduced rate of postoperative complications and shorter hospital stay.[22]

However, it is also a "chicken-egg question" considering a hypothetical case of a patient with a delayed chest tube removal and a worse outcome. There are two likely questions to be asked. Was that unfavorable outcome related to the delayed removal of the chest tube, the "old habit"?, or was it a result of a related complication (e.g., persistent air leak)? In the first case, the worse outcome is a result of "non-adherence to ERATS recommendation"; in the second case, delayed removal was not a reason, but it was a result of the complication.

Fifth, postoperative pain—as mentioned in the previous part of the article—is one of the most important influencers on the outcome in thoracic surgery.[25] It was therefore somehow surprising, that the elements about pain management in the different ERATS protocols failed to find any common way to go through. On the other hand, the recommendations on the use of different analgesia techniques are too blurred among the different ERATS protocols to be helpful. In this manner, the joint consensus was an exception with rather concrete and structured suggestions [Table 1].[15] Suggestions for pain treatment in other protocols range from recommended use of the intercostal nerve blockade to the consideration of liposomal bupivacaine and other modalities. There are almost endless variations of possible analgesia methods, and thousands of studies have been published about pain in thoracic surgery.[25] Unfortunately, the majority of them have focused on "visual analog scale" (VAS), sometimes even on only VAS during rest. This explains why there is still insufficient data and hence insufficient evidence supporting the effect of any analgesia technique on postoperative recovery and overall outcome. In light of the current scientific supporting evidence, it can be concluded that:

- Open thoracotomy is one of the most painful operations which can potentially negatively impact the postoperative respiratory functions. Although thoracoscopic surgery is less painful, postoperative analgesia for thoracoscopic surgery is almost as important as in open thoracotomies. The application of the different analgesia techniques in different operations (e.g. considering the use of TEA for open thoracotomy and paravertebral block for thoracoscopic surgery) can be rational also for enhanced recovery.
- Suggested debatable recommendations on ERATS would negatively affect the adherence to the other elements of the ERATS protocols (e.g., with the application of intercostal nerve blockade for analgesia, cessations of opioids on 3rd postoperative day would not likely be possible).
- There are obvious disadvantages for using TEA, especially regarding the quality "recovery" (e.g., the associated urinary retention, negative impacts on bowel mobility, etc.). However, there are still very few data showing the noninferiority of other regional analgesia techniques to the TEA, especially if a combination of a local anesthetic and opioid was used with TEA.
- "Multimodal analgesia," as suggested by the joint consensus, should be followed because the pain pathway after thoracic operations is also multivariate. Combinations of systemic non-opioid agents (such as nonsteroidal anti-inflammatory drugs, ketamine, dexamethasone, dexmedetomidine, etc.) with regional analgesia techniques can lead to additive analgetic effects, by decreasing the unwarranted effects.
- The introduction of ultrasound in the daily practice of thoracic anesthesia has opened a new horizon for new regional blocks such as erector spinae plane block and serratus anterior plane block. Whether these new blocks can achieve a further improvement in "recovery," will be the topic of future studies.

Yet, the blurry and noncomparable suggestions in different protocols should motivate us to implement new studies with a more pragmatic and rational outcome focusing on the enhanced recovery after thoracic surgery.

Sixth, a similar challenge is to be found concerning intraoperative ventilation. Although there is a consensus in the majority of the protocols for "protective one-lung ventilation (OLV)," we still do not know the "best" ventilation method to achieve an enhanced recovery. Similar to the studies on postoperative analgesia focusing only on VAS at rest as the primary outcome, thousands of studies have examined the effects of different ventilation interventions on oxygenation or release of the inflammatory mediators during OLV.

The authors do not mean that these studies are less worthy, but the primary reason that we do not have a concrete recommendation for the ventilatory setting in ERATS protocols is that no sufficient strong studies are examining the effects of OLV strategies in important postoperative clinical outcomes and recovery.

Protective ventilation is defined generally as a bundle of low tidal volume, positive-end expiratory pressure (PEEP), low driving pressure, and recruitment maneuvers (RM). But this bundle is again associated with further questions as follows[26]:

- Low tidal volume: How low is low? It is not "the lower, the better." The same question can be extrapolated for the low driving pressure.
- What is the "Best PEEP" level? How should/can PEEP be titrated?
- Is RM required in every patient? If needed, when and how RM should be applied?
- Do the elements of the bundle contribute similarly to the "protection" if they have any protective effects?
- Finally, can the protective ventilation strategies improve the postoperative outcome and recovery? A recent study has shown that a PEEP titration achieving the highest compliance (i.e., the lowest driving pressure for the same tidal volume) was associated with a reduction in postoperative pulmonary complication.[27] There is another currently recruiting large international comparative RCT examining the effects on low-and-high PEEP level on the clinical outcome.[28]

Seventh, as a very concrete obligation, fluid overload should be avoided in any case in thoracic surgery. On the other hand, a suggestion like "the less, the better" is also not appropriate because the supporting evidence for "fluid restriction" is weaker than its good reputation. "There is no third space in the lung" is also a confusing argument despite being correct: There is no third space anywhere in the body; "third space" should be considered as an urban myth.[29] Even the definitions of "liberal" and "restrictive" regimens differ essentially among the different studies. Adopting goal-directed fluid management approaches (where the "goal" is euvolemia) has been shown beneficial.[30] Therefore, the recommendation of the joint consensus[15] "Very restrictive or liberal fluid regimes should be avoided in favor of euvolemia" appears to be a more rational suggestion than literally "low" volumes that would increase the risk of failure of other organs. Not surprisingly, Peter Slinger, also a coauthor of the joint consensus, has quoted: "with intravenous fluids, we can make it worse, but we do not cause it."[31]

Finally, the authors want to underline an important note that "enhanced" does not mean necessarily "fast" discharge.

Conclusion

ERAS is a pragmatic approach with a very simple but not an easy target for an "enhanced recovery." The most important difference that it aims to achieve is to create an "awareness" of the clinicians working in perioperative medicine. From this point of view, it does not matter even if ERAS (or ERATS) would not improve the outcome in some well-organized centers,[16] as most of the ERATS elements were already considered in place before the formal implementation of such a program. Even in these centers, just "thinking of ERATS" would help to change the philosophy. This change would help primarily to improve the general outcome in daily practice (literally "enhanced recovery") and also motivate the academicians to organize new studies with the aim of improving the protocols.

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Conflicts of interest

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References

1. Fearon KC, Ljungqvist O, Von Meyenfeldt M, Revhaug A, Dejong CH, Lassen K, *et al*. Enhanced recovery after surgery: A consensus review of clinical care for patients undergoing colonic resection. Clin Nutr 2005;24:466–77.
2. Gustafsson UO, Scott MJ, Schwenk W, Demartines N, Roulin D, Francis N, *et al*. Guidelines for perioperative care in elective colonic surgery: Enhanced Recovery After Surgery (ERAS) Society recommendations. World J Surg 2013;37:259–84.
3. Nygren J, Thacker J, Carli F, Fearon KC, Norderval S, Lobo DN, *et al.* Guidelines for perioperative care in elective rectal/pelvic surgery: Enhanced Recovery After Surgery (ERAS) Society recommendations. World J Surg 2013;37:285–305.
4. Cerantola Y, Valerio M, Persson B, Jichlinski P, Ljungqvist O, Hubner M, *et al*. Guidelines for perioperative care after radical cystectomy for bladder cancer: Enhanced Recovery After Surgery (ERAS) society recommendations. Clin Nutr 2013;32:879–87.
5. Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery. JAMA Surg 2017;152:292.
6. Paci P, Madani A, Lee L, Mata J, Mulder DS, Spicer J, *et al.* Economic impact of an enhanced recovery pathway for lung resection. Ann Thorac Surg 2017;104:950–7.
7. Nicholson A, Lowe MC, Parker J, Lewis SR, Alderson P, Smith AF. Systematic review and meta-analysis of enhanced recovery programmes in surgical patients. Br J Surg 2014;101:172–8.
8. Li L, Jin J, Min S, Liu D, Liu L. Compliance with the enhanced recovery after surgery protocol and prognosis after colorectal cancer surgery: A prospective cohort study. Oncotarget 2017;8:53531–41.
9. Giménez-Milà M, Klein AA, Martinez G. Design and implementation of an enhanced recovery program in thoracic surgery. J Thorac Dis 2016;8(Suppl 1):S37-45.
10. Hubert J, Bourdages-Pageau E, Paradis Garneau CA, Labbé C, Ugalde PA. Enhanced recovery pathways in thoracic surgery: The Quebec Experience. J Thorac Dis 2018;10(Suppl 4):S583-90.
11. Eustache J, Ferri LE, Feldman LS, Lee L, Spicer JD. Enhanced recovery after pulmonary surgery. J Thorac Dis 2018;10(Suppl 32):S3755-60.
12. Gonzalez M, Abdelnour-Berchtold E, Perentes JY, Doucet V, Zellweger M, Marcucci C, *et al*. An enhanced recovery after surgery program for video-assisted thoracoscopic surgery anatomical lung resections is cost-effective. J Thorac Dis 2018;10:5879–88.
13. Rogers LJ, Bleetman D, Messenger DE, Joshi NA, Wood L, Rasburn NJ, *et al*. The impact of enhanced recovery after surgery (ERAS) protocol compliance on morbidity from resection for primary lung cancer. J Thorac Cardiovasc Surg 2018;155:1843–52.
14. Van Haren RM, Mehran RJ, Mena GE, Correa AM, Antonoff MB, Baker CM, *et al.* Enhanced recovery decreases pulmonary and cardiac complications following thoracotomy for lung cancer. Ann Thorac Surg 2018;106:272–9.
15. Batchelor TJP, Rasburn NJ, Abdelnour-Berchtold E, Brunelli A, Cerfolio RJ, Gonzalez M, *et al*. Guidelines for enhanced recovery after lung surgery: Recommendations of the Enhanced Recovery After Surgery (ERAS®) Society and the European Society of Thoracic Surgeons (ESTS). Eur J Cardiothorac Surg 2019;55:91-115.
16. Brunelli A, Thomas C, Dinesh P, Lumb A. Enhanced recovery pathway versus standard care in patients undergoing video-assisted thoracoscopic lobectomy. J Thorac Cardiovasc Surg 2017;154:2084–90.
17. Madani A, Fiore JF Jr, Wang Y, Bejjani J, Sivakumaran L, Mata J, *et al.* An enhanced recovery pathway reduces duration of stay and complications after open pulmonary lobectomy. Surgery 2015;158:899-908; discussion 908-10.
18. Semenkovich TR, Hudson JL, Subramanian M, Kozower BD. Enhanced recovery after surgery (ERAS) in thoracic surgery. Semin Thorac Cardiovasc Surg 2018;30:342–9.
19. Casans Francés R, Ripollés Melchor J, Calvo Vecino JM; Grupo Español de Rehabilitación Multimodal GERM/ERAS-Spain. Is it time to integrate patient blood management in ERAS guidelines? Rev Esp Anestesiol Reanim 2015;62:61-3.

20. Teeter EG, Kolarczyk LM, Popescu WM. Examination of the enhanced recovery guidelines in thoracic surgery. Curr Opin Anesthesiol 2019;32:10–6.
21. Bertolaccini L, Rocco G, Crisci R, Solli P. Enhanced recovery after surgery protocols in video-assisted thoracic surgery lobectomies: The best is yet still to come? J Thorac Dis 2018;10(Suppl 4):S493–6.
22. Forster C, Doucet V, Perentes JY, Abdelnour-Berchtold E, Zellweger M, Marcucci C, *et al*. Impact of compliance with components of an ERAS pathway on the outcomes of anatomical VATS pulmonary resections. J Cardiothorac Vasc Anesth 2020;34:1858–66.
23. Huang A, Yeung JC, Slinger PD. Enhanced recovery after lung resection surgery: Knowing what we can do… and doing it. J Cardiothorac Vasc Anesth 2020;34:1867-9.
24. Egbert LD, Battit GE, Welch CE, Bartlett MK. Reduction of postoperative pain by encouragement and instruction of patients. A study of doctor– patient rapport. N Engl J Med 1964;270:825–7.
25. Şentürk M. Acute and chronic pain after thoracotomies. Curr Opin Anaesthesiol 2005;18:1-4.
26. Senturk M, Slinger P, Cohen E. Intraoperative mechanical ventilation strategies for one-lung ventilation. Best Pract Res Clin Anaesthesiol 2015;29:357-69.
27. Belda J, Ferrando C, Garutti I. The effects of an open-lung approach during one-lung ventilation on postoperative pulmonary complications and driving pressure: A descriptive, multicenter national study. J Cardiothorac Vasc Anesth 2018;32:2665–72.
28. Kiss T, Wittenstein J, Becker C, Birr K, Cinnella G, Cohen E, *et al*. Protective ventilation with high versus low positive end-expiratory pressure during one-lung ventilation for thoracic surgery (PROTHOR): Study protocol for a randomized controlled trial. Trials 2019;20:213.
29. Sentürk M, Sungur MO, Sungur Z. Fluid management in thoracic anesthesia. Minerva Anestesiol 2017;83:652-9.
30. Assaad S, Kyriakides T, Tellides G, Kim AW, Perkal M, Perrino A. Extravascular lung water and tissue perfusion biomarkers after lung resection surgery under a normovolemic fluid protocol. J Cardiothorac Vasc Anesth 2015;29:977–83.
31. Slinger PD. Postpneumonectomy pulmonary edema: Good news, bad news. Anesthesiology 2006;105:2-5.