

**Table S1** Perioperative thoracic ERAS protocol

ERAS objective	Protocol
Carbohydrate loading and NPO status	Two bottles of drink provided between 7 pm–midnight the night before and 1 bottle 3 hours before surgery Clear liquids up to 2 hours pre-op
Pain meds and sedation	Gabapentin 300 mg and Tylenol 975 mg morning of surgery Use midazolam sparingly Limit the amount of opiates to a total of 100 mcg of Fentanyl and 1 mg Dilaudid (Intraop and PACU). Do not administer any more narcotic without attending approval Give a bolus of Ketamine 0.5 mg/kg ideal body weight followed by infusion at 0.3 mg/kg/hour intraoperatively. Shut off the infusion half hour before the end of the procedure Give a magnesium load of 30 mg/kg over 10 min and dexamethasone 4 mg after induction Use multimodal analgesia to minimise opiate use Intercostal nerve blocks with Exparel at the beginning of the case Consider thoracic epidurals for thoracotomies. Give 1 g of IV Tylenol at least 4–6 hours after the initial PO Tylenol Give 15 or 30 mg of Ketorolac after discussion with the surgeon 30 minutes before the end of the procedure
Lines	Place arterial line pre-operatively if indicated unless you have an anxious patient or difficult arterial line (several attempts)
Maintain normothermia	Pre-op heating blankets Intraoperative Bair huggers
DVT prophylaxis	Compression boots and subcutaneous heparin
Double lumen ETT	ETT sizing based off patient sex or airway measurements Refer to Tables S2,S3 for sizing criteria
Ventilation	Use standard size of double lumen tubes based on sex and height (consider tracheal diameter on CT for appropriate sizing) (refer to tables above) Use no more than 4–6 mL/kg tidal volume based on ideal body weight Optimize PEEP to get the best compliance with lower driving pressure (ideally below 15). Driving pressure is tidal volume/compliance and can be calculated with new anesthesia machines Recruitment maneuvers Lower the FiO <sub>2</sub> while on OLV Lower FiO <sub>2</sub> when going from OLV to 2 lung ventilation to reduce reperfusion injury Decrease the duration of one lung ventilation
Antibiotic prophylaxis	Antibiotics should be administered within 60 minutes (prior to) of skin incision
Fluid management	Consider any preop risk factors for acute tubular necrosis Maintain euolemia Give 4–5 mL/kg/hour in addition to replacing blood losses for VATS lobectomies/wedges Give 2 mL/kg/hour for pneumonectomies in addition to replacing blood loss (1:1). Ideally less than 2 L for the case Selected cases such as septic patients do not require fluid restriction Maintain urine output of 0.3–0.5 cc/kg/hour Use PPV as a guide (ideally PPV <12)
Atrial fibrillation prevention	Continue beta blockers in the postoperative period if patient is on beta blockers
Prevention of post-op nausea and vomiting	Give dexamethasone 4 mg after induction Give Zofran 4 mg prior to emergence Consider using scopolamine patch in high risk patients
PACU management	CXR in PACU Step 1: administer Dilaudid. Limit the total amount to a maximum of 1 mg (If 0.4 mg of Dilaudid is given in OR order only 0.6 mg for PACU use) Step 2: continue ketamine infusion in the PACU if patient continues to be in pain after maximum dose of Dilaudid. Follow Ketamine PACU order set with varying dose ranges depending on the pain scores Step 3: start IV PCA Dilaudid in addition to PO pain medications ordered by the surgical team (if patient continues to be in pain after 1 mg of Dilaudid and Ketamine infusion) Step 4: consider ICU admission in order to continue ketamine infusion if the patient continues to be in pain Follow the postoperative thoracic surgical ERAS pathway

ERAS, enhanced recovery after surgery; NPO, nothing by mouth; PACU, post-anesthesia care unit; IV, intravenous; DVT, deep vein thrombosis; ETT, endotracheal tube; CT, computed tomography; PEEP, positive end expiratory pressure; FiO<sub>2</sub>, fraction of inspired oxygen; OLV, one lung ventilation; VATS, video-assisted thoracic surgery; PPV, pulse pressure variation; CXR, chest X-ray; OR, operating room; PCA, patient-controlled analgesia; PO, oral; ICU, intensive care unit.

**Table S2** Endotracheal tube sizing criteria by patient sex

Sex	Height >170 cm	Height <170 cm	Height >160 cm	Height <160 cm
Male	41 F	39 F	–	–
Female	–	–	37 F	35 F

**Table S3** Endotracheal tube sizing criteria by airway measurements

Tracheal width (mm)	Predicted left bronchus width (mm)	DLT size	OD of main body of DLT (mm)	OD of left lumen of DLT (mm)
≥18	≥12.2	41 F	14–15	10.6
≥16	≥10.9	39 F	13–14	10.1
≥15	≥10.2	37 F	13–14	10.0
≥14	≤9.5	35 F	12–13	9.5

DLT, double lumen tube; OD, outer diameter.

**Table S4** Baseline cohort characteristics

Patient variables	Pre-ERAS (n=193)	Post-ERAS (n=249)	P value
Male sex	72 [37]	96 [39]	0.79
Race			0.33
Asian	6 [3.1]	4 [1.6]	
Black	3 [1.6]	9 [3.6]	
Other	3 [1.6]	7 [2.8]	
White	180 [94]	229 [92]	
Hispanic or Latino ethnicity	9 [4.7]	13 [5.2]	0.80
Primary payor			0.50
Private	96 [50]	112 [46]	
Government	97 [50]	129 [54]	
Age (years)	65 [10]	66 [10]	0.45
BMI (kg/m <sup>2</sup> )	28 [5.7]	29 [7.3]	0.53
Preoperative FEV1 (% predicted)	84.9 [19.7]	83.3 [19.0]	0.42
Weight loss in past 3 months	0.3 [1.9]	0.1 [0.9]	0.21
Pack-years of cigarette use	44 [24]	43 [24]	0.90
Zubrod ECOG score			0.07
0	122 [63]	175 [71]	
1	60 [31]	68 [27]	
2	11 [5.7]	5 [2.0]	
Functional status			0.16
Independent	45 [94]	231 [93]	
Partially dependent	2 [4.2]	17 [6.9]	
Totally dependent	1 [2.1]	0	
Hypertension	130 [67]	148 [59]	0.09
Congestive heart failure	3 [1.6]	5 [2.0]	0.27
Coronary artery disease	42 [22]	43 [17]	0.23
Pulmonary hypertension	6 [3.1]	5 [2.0]	0.54
Interstitial fibrosis	1 [0.5]	3 [1.2]	0.45
DVT/PE	1 [2.1]	3 [1.2]	0.51
Cerebrovascular history			0.99
Cerebrovascular accident	2 [1.0]	3 [1.2]	
Known disease, no events	0	1 [0.4]	
No cerebrovascular disease history	186 [96]	238 [96]	
Transient ischemic attack	5 [2.6]	7 [2.8]	

**Table S4** (continued)

**Table S4** (continued)

Patient variables	Pre-ERAS (n=193)	Post-ERAS (n=249)	P value
Diabetes	34 [18]	39 [16]	0.58
Currently on dialysis	1 [0.5]	0	0.44
Coexisting cancer	2 [4.2]	13 [5.2]	0.99
Cigarette smoking			0.97
Current smoker	56 [29]	70 [28]	
Never smoked	30 [16]	38 [15]	
Former smoker	107 [55]	141 [57]	
Living status			0.017
Assisted living	1 [2.1]	0	
Lives alone	5 [10]	57 [23]	
Lives with family or friend	42 [88]	191 [77]	
Operation status			0.020
Elective	193 [100]	241 [97]	
Emergent	0	1 [0.4]	
Urgent	0	7 [2.8]	
ASA classification			0.030
II	32 [17]	25 [10]	
III	150 [78]	217 [87]	
IV	11 [5.7]	7 [2.8]	
Category of disease			0.008
Non-cancer	17 [8.8]	43 [18]	
Cancer	176 [91]	202 [82]	
Primary procedure			0.014
Lobectomy	127 [66]	140 [56]	
Segmentectomy	5 [2.6]	22 [8.8]	
Bilobectomy	1 [0.5]	4 [1.6]	
Wedge resection	60 [31]	83 [33]	
Minimally invasive procedure	193 [100]	249 [100]	
Procedure group			0.62
Anatomic	133 [69]	166 [67]	
Non-Anatomic	60 [31]	83 [33]	
Primary lobe <sup>†</sup>			0.28
Upper	83 [54]	113 [58]	
Middle	9 [5.8]	17 [8.7]	
Lower	63 [41]	65 [33]	
Operative approach			<0.001
VATS	175 [91]	136 [55]	
Robotic	18 [9.3]	113 [45]	

Data are presented as number of patients with corresponding percentage [%] or mean [standard deviation]. <sup>†</sup>, lobe data not collected for benign or metastatic disease. There were 38 (20%) unspecified lung resections in the pre-ERAS group and 54 (22%) in the ERAS group. ERAS, enhanced recovery after surgery; BMI, body mass index; FEV1, forced expiratory volume in one second; ECOG, Eastern Cooperative Oncology Group; DVT, deep vein thrombosis; PE, pulmonary embolism; ASA, American Society of Anesthesiologists; VATS, video-assisted thoracic surgery.

**Table S5** Secondary outcomes

Variables	Pre-ERAS (n=193)	Post-ERAS (n=249)	P value
Discharge outcomes			
Discharged alive	193 [100]	249 [100]	–
Discharge location			0.99
Home	184 [95]	236 [95]	
Extended/transitional care/rehab	8 [4.2]	10 [4.0]	
Nursing home	1 [0.5]	2 [0.8]	
Other	0	1 [0.4]	
Discharged with chest tube	2 [1.0]	10 [4.0]	0.06
Discharged with Foley catheter	1 [0.5]	3 [1.2]	0.64
Discharged with home oxygen	2 [4.2]	24 [9.6]	0.28
Pulmonary complications			
Air leak greater than 5 days	19 [9.8]	22 [8.8]	0.72
Pneumonia	4 [2.1]	4 [1.6]	0.73
Pneumothorax (requiring chest tube reinsertion)	10 [5.2]	4 [1.6]	0.033
Acute respiratory distress syndrome	1 [0.5]	1 [0.4]	0.99
Respiratory failure	2 [1.0]	6 [2.4]	0.48
Bronchopleural fistula	0	1 [0.4]	0.99
Initial vent support >48 hours	0	0	–
Pulmonary embolus	0	0	–
Empyema requiring treatment	1 [0.5]	0	0.44
Other pulmonary event	5 [2.6]	4 [1.6]	0.51
Cardiovascular complications			
Atrial arrhythmia requiring treatment	7 [3.6]	13 [5.2]	0.42
Ventricular arrhythmia requiring treatment	3 [1.6]	2 [0.8]	0.66
DVT requiring treatment	0	2 [0.8]	0.51
Myocardial infarction	0	0	–
Other complications			
Urinary tract infection	1 [0.5]	6 [2.4]	0.14
Urinary retention	18 [9.3]	31 [12]	0.30
Unanticipated post-operative invasive procedure	4 [2.1]	9 [3.6]	0.77
Unexpected return to the OR	5 [2.6]	9 [3.6]	0.54
Unexpected admission to ICU	7 [3.6]	6 [2.4]	0.57
Clostridium difficile infection	0	2 [0.8]	0.51
Sepsis	1 [0.5]	0	0.44
Surgical site infection			0.81
None	190 [98]	246 [99]	
Superficial	2 [1.0]	3 [1.2]	
Deep	1 [0.5]	0	
Tracheostomy	0	0	–

Data are presented as number of patients with corresponding percentage [%] or as mean [standard deviation]. ERAS, enhanced recovery after surgery; DVT, deep vein thrombosis; OR, operating room; ICU, intensive care unit.

**Table S6** Outcomes after robotic versus VATS lung resection

Outcome	VATS (n=311)	Robotic (n=131)	P value
Length of stay (days)	4.0 (2.0, 6.0)	4.0 (3.0, 6.0)	0.76
Length of stay (days)	5.1 (7.4)	4.6 (3.3)	0.37
Postoperative events occurred	98 [32]	48 [37]	0.30
ICU admission status	35 [11]	12 [9.2]	0.51
30-day hospital readmission	31 [10]	8 [6.1]	0.44
30-day mortality	0	0	–

Data are presented as number of patients with corresponding percent [%], median (interquartile range), or mean (standard deviation). VATS, video-assisted thoracic surgery; ICU, intensive care unit.

**Table S7** Summary of main findings of thoracic surgery ERAS protocols

Authors	Year	Study type	Inclusion criteria	Sample size	Control LOS (days)	ERAS LOS (days)	Key findings	Observations
Madani <i>et al.</i> (7)	2015	Retrospective	Open lobectomy only	127 controls 107 ERAS	6 (median)	7 (median)	Decreased LOS (1 day) Decreased total complications	No VATS or non-anatomic resections
Scarci <i>et al.</i> (27)	2016	Retrospective	All lung resections	171 controls 154 ERAS	11.7 (mean)	5.2 (mean)	Decreased LOS (6.5 days) Decreased ICU admissions	Higher patient satisfaction in ERAS group
Brunelli <i>et al.</i> (12)	2017	Retrospective	VATS lobectomy and segmentectomy	365 controls 235 ERAS	4 (median)	5 (median)	No significant differences observed	Did not include non-anatomic resections
Rogers <i>et al.</i> (4)	2018	Prospective	All lung resections	422 ERAS	–	5 (median)	Increased morbidity associated with decreased ERAS compliance	No historical control group (study not designed to measure impact of ERAS implementation)
Van Haren <i>et al.</i> (5)	2018	Retrospective	All lung resections	1,615 controls 342 ERAS	5 (median)	4 (median)	Decreased LOS (1 day) Decreased ICU admissions Decreased cardiac and pulmonary complications	Included analysis of 929 patients in “transitional period” Less benefit to ERAS observed in minimally invasive subgroup Included analysis of 929 patients in “transitional period”
Martin <i>et al.</i> (8)	2018	Retrospective	All pulmonary, pleural, and mediastinal operations	162 controls 81 ERAS	3 (median)	2 (median)	Trend-level difference in LOS No difference in VATS complication rates	Decreased total hospital costs
Tahiri <i>et al.</i> (11)	2020	Prospective with historical controls	VATS lobectomy only	98 controls 98 ERAS	5 (median)	3 (median)	Decreased LOS (2 day)	No non-anatomic resections No difference in complications or readmissions
Strobel <i>et al.</i> (9)	2023	Retrospective	All elective pulmonary, pleural, and mediastinal operations	160 controls 339 ERAS	3 (median)	3 (median)	No difference in LOS Decreased 3-month opioid use	–
Turner <i>et al.</i> (10)	2023	Retrospective	All lung resections	240 controls 85 ERAS	5 (median)	4 (median)	Decreased LOS (1 day) Decreased short and long-term opioid use Decreased time in ICU	No difference in complications or readmissions
Lee <i>et al.</i> (20)	2022	Prospective	All elective thoracic surgeries	342 controls 352 ERAS	6.2 (mean)	4.5 (mean)	Trend-level difference in LOS Decreased incidence of adverse events	Included esophageal surgery

ERAS, enhanced recovery after surgery; LOS, length of stay; VATS, video-assisted thoracic surgery; ICU, intensive care unit.

## References

27. Scarci M, Solli P, Bedetti B. Enhanced recovery pathway for thoracic surgery in the UK. *J Thorac Dis* 2016;8:S78-83.