

Appendix 1 The final thoracic ERAS protocol implemented throughout UCHHealth**Thoracic Surgery ERAS Protocol
University of Colorado Health****Pre-surgery clinic protocol**

1. Routine pre-operative clinical workup
2. Nutrition assessment
 - a. Malnutrition Screening Tool – performed by CNAs
 - b. Impact Advance Recovery – Given to all patients in pre-op clinic
 - i. One package- 5 days w/3 drinks per day = 15 total supplements
 - ii. Drink for the 5 days prior to surgery
3. Functional status assessment
 - a. Low risk/medium risk
 - i. Home PT program
 1. Developed for 14-day and 28-day time intervals
 2. Packet will be disseminated either in person or virtually through my health connection
 - b. High risk
 - i. If patient requires PPS for planned operation, referral to pre-habilitation and pulmonary rehab
 - ii. Ideally for 4 weeks prior to surgery if possible but as available with patient operative timing
 - c. All patients receive an incentive spirometer in pre-operative clinic
4. Risk assessment
 - a. Use of SURPAS or ACS NSQIP risk calculator
 - b. Education, disposition recommendation, and potential pre-operative risk mitigation
 - c. If moderate/high risk, refer to anesthesia pre-operative clinic for optimization
5. Correction of anemia pre-operatively
 - a. If anemic on CBC- prescribe oral iron supplementation- first line for iron deficiency anemia
6. Patient education and counseling
 - a. Written communication including patient education and checklist will be given to patient at clinic
 - i. Patient checklist will assist patient with directions to help comply with ERAS tasks and goals
 - ii. Formalized thoracic ERAS guidebook in development
7. Smoking cessation x4 weeks if possible – education and resources provided
8. Alcohol cessation x4 weeks if possible – education and resources provided

Pre-operative management

1. Carbohydrate heavy meal on night before surgery
 - a. Continue clear liquids until 2h prior to check-in
 - i. Instruct patients to drink clears up until 2hr before arrival time
 - b. Boost Breeze
 - i. One supplement- given to patient in pre-op clinic
 - ii. Only non-diabetic patients
 - iii. Instruct patients to drink 2 hours prior to arrival time (or 2 hours prior to surgery for first start cases)
2. Shower night before and morning of surgery with soap
3. Mechanical and pharmacologic deep venous thrombosis prophylaxis for all patients
 - a. TED hose, SCD's
 - b. SQH 5000mg pre-operatively
 - i. hold administration until after regional technique placement, if applicable

4. Routine prophylaxis with intravenous antibiotics within 60 minutes of, but prior to, skin incision.
 - a. IV cefazolin 1st line, weight based
 - i. <50 kg-1 g; 50-120 kg-2 g; >120 kg-3 g
 - b. IV vancomycin 2nd line
 - i. Vancomycin: 15 mg/kg
5. Pre-surgery medication bundle
 - a. Tylenol-1,000 mg PO/IV pre-operatively
 - b. Celebrex PO 400 mg (<65YO), 200 mg (>65), contraindicated if eGFR <30
 - c. Gabapentinoid
 - i. Option 1: Lyrica PO 150 mg, 75 mg if >65
 - ii. Option 2: Gabapentin 300 mg (age <65, >50 kg), 100 mg (age >65, weight <50 kg)
 1. Renal dosing for eGFR <30
 - d. Pepcid 20 mg IV
6. Pre-operative warming
 - a. Stryker air blankets–given to patients in pre-op holding area

Peri-operative management

1. Surgical Protocol
 - a. Hair clipping over other hair removal methods, if required
 - b. Chloraprep skin preparation preferred over betadine prep
 - c. Surgical approach
 - i. For early stage lung cancer, a minimally invasive approach is recommended
 - ii. For thoracotomies, a muscle sparing incision should be performed
 - iii. For thoracotomies, rib re-approximation should be performed while sparing inferior intercostal nerve
 - d. Chest tube placement
 - i. Placement of one 20-28 Fr chest tube for any anatomic resection up to and including lobectomies
2. Anesthesia protocol
 - a. Limit pre-operative sedatives to reduce anxiety especially in patients >65 years old
 - b. Airway
 - i. Double Lumen ETT (35-41 Fr) - 1st Line
 - ii. Bronchial Blockers - 2nd Line
 - iii. ETT placement confirmed with fiberoptic scope
 - c. Lung optimization
 - i. Lung Protective Strategy During Single Lung Ventilation
 1. Tidal Volumes 4-6 mL/kg
 2. PEEP 5-10 cmH₂O
 - ii. Recruitment maneuvers after induction
 - iii. Repeat recruitment maneuvers after lung reinflation
 - iv. Goal FiO₂- 94-99%
 - v. Goal EtCO₂ 30-35
 - d. Goal directed fluid therapy
 - i. Maintenance of euvolemia
 1. Weight-based administration of IV fluids
 - a. Consider adjusted body weight (AdjBW) for obese patients
 - b. $AdjBW = (ABW - IBW) \times 0.4 + IBW$
 2. Balanced crystalloid solutions are preferred over 0.9% saline
 3. Consider 5% Albumin after 10 mL/kg of crystalloid has been administered or in patients with known hypoalbuminemia
 4. Intraoperative fluids should be administered at 2-3 mL/kg/hr

- a. Vasopressors should be administered early to counteract the vasodilatory effects of general and neuraxial anesthesia
 - b. Consider 5-10 mL/kg fluid bolus if the patient is hypotensive after the induction of anesthesia despite vasopressor administration
 - c. In patients with a Foley catheter, goal urine output should be 0.5 mL/kg/hr
 - d. Thoracotomy patients are expected to demonstrate greater intraoperative fluid requirements compared to VATS/robotic patients
 - e. Significant blood loss should be replaced in a 1:1 ratio with 5% Albumin until a transfusion threshold is reached
- e. Intra-operative medication bundle
- i. Dexamethasone IV 8-10 mg
 - ii. Sedation
 - 1. Option 1: propofol infusion
 - 2. Option 2: dexmedetomidine infusion
 - 3. Minimize fentanyl as able
 - 4. Volatile anesthetic throughout operation
 - iii. Ketamine
 - 1. For chronic pain patients – APS to manage
 - 2. Dose 0.5 mg/kg bolus at incision, 0.1 mg/kg/hr infusion (3-8 mg/hr, adjusted in PACU, then continue to floor x24hr if no pain catheter or not functioning)
- f. Regional Pain control
- i. VATS/robotic.
 - 1. Intraoperative intercostal nerve blocks performed by surgeon
 - ii. Thoracotomy
 - 1. First Line Thoracic epidural catheter with ropivacaine, dosing per anesthesia, confirm dermatome level
 - 2. Second line: Ketamine infusion (dosing as above)
 - 3. Third line- If thoracic epidural is contraindicated- ESP catheter infusion
 - 4. Fourth line- may add fentanyl PCEA in conjunction to ESP or epidural infusion
 - 5. Fifth line- If no regional/PNB catheter- lidocaine infusion
 - iii. Planning to engage UCHHealth leadership to obtain liposomal bupivacaine in future
- g. Urinary drainage
- i. Foley catheter not indicated unless planned thoracotomy, TEA placement below T9 level, or expected case duration >4 hours
 - ii. Discontinue POD0 or POD1
- h. Hypothermia prevention
- i. Continuous core temperature measurement intraoperatively
 - ii. Convective heating device intraoperatively
 - iii. Goal temperature >35.9 °C
- i. Hyperglycemia protocol
- i. Check BGL in pre-op
 - ii. If pre-op BGL >180, RN to notify anesthesia team to initiate sliding scale insulin lispro
 - 1. Sensitive SSI
 - a. Type 1 DM
 - b. Stress hyperglycemia in non-diabetic
 - c. BMI <30
 - 2. Resistant SSI
 - a. Type 2 DM
 - b. Chronic home steroid use
 - c. Overweight/obese

- d. >60 units insulin/day at home
- iii. If Pre-op BGL >180 and/or Insulin administered in Pre-op, perform an accucheck immediately after patient stabilized after induction and then q1hr
- iv. If procedure lasts >2 hours, intra-op accuchecks at least every q2hr for ALL ERAS patients (regardless of medical history)
- v. If Intra-op accucheck \geq 180, then initiate treatment (bolus + continuous infusion of regular insulin)
- vi. D/C continuous infusion before transport to PACU
- vii. Continue at least Q1hr blood sugar check while utilizing Insulin (regular)

Post-operative management

1. Post-operative disposition
 - a. Minimally invasive surgery
 - a. Floor disposition (unless intra-operative assessment/ pre-operative morbidity indicates ICU need)
 - b. Open surgery
 - a. Driven by pre-operative risk assessment, intra-operative assessment
2. Pain Control
 - a. Tylenol 1,000 mg q8hr PO/IV
 - b. Post-operative NSAIDs
 1. Option 1: Toradol 15 mg q6hr IV x8 doses (first dose 8 hours after pre-operative NSAID), then ibuprofen 600mg q6hr PO (contraindicated if eGFR <30)
 2. Option 2: Celebrex PO 200mg BID (<65YO), 100 mg PO BID (>65), contraindicated if eGFR <30
 - c. Gabapentinoid
 - a. Option 1: Lyrica 75 mg PO BID (<65YO), 25 mg PO BID (>65YO)
 - b. Option 2: Gabapentin 300 mg TID (renally dose for eGFR <30), initiate 8hours after pre-operative Lyrica
 - d. OK to add flexeril 5mg TID PRN if patient is having muscle spasms
 - e. Emla cream or lidocaine patches prn for chest tube associated pain
 - f. Non-pharmaceutical pain control- Ice packs, heat packs, repositioning, mobilization
 - g. Regional pain control
 1. VATS/robotic- intra-operative blocks or single shot paravertebral block only
 2. Thoracotomy- TEA with APS management as above
 - a. Goal catheter removal- POD2 or day of final chest tube removal, whichever is later
 - h. Chronic pain patients
 - a. If ketamine initiated, managed by APS
 - b. If initiated, continue ketamine gtt 3-8 mg/hr as titrated in recovery x24 hours if no regional pain catheter or having continued pain
 - i. Opioids
 - a. Oxycodone IR 5-10 mg PO q4hr PRN
 - b. Limit IV narcotics as able
 - c. No routine patient-controlled analgesia
 - d. Chronic pain patients- continue home regimen + additional oxycodone IR prn for breakthrough pain
3. Recovery unit
 - a. Chest x-ray, if no large pneumothorax or air leak, chest tube to water seal (excluding NTM patients, who will remain on suction)
4. Atrial fibrillation prophylaxis
 - a. Continue home beta blockers in the post-operative period
 - a. If patients are receiving epidural anesthesia, should start post-operatively at half of home dose with hold parameters
 - b. All anatomic lung resections not on home beta blockers
 - a. Diltiazem 30 mg PO every 6 hours with hold parameters, can up titrate as needed
 - c. Persistent atrial fibrillation with rapid ventricular rate

- a. Amiodarone 1,050 mg by continuous infusion × 24 hr, followed by 400 mg PO BID x6 days
- b. Contraindicated in pneumonectomy patients
- 5. Chest tube management
 - a. Chest tube removal with up to 450 cc/24 hr of serosanguinous output if no air leak
 - b. Digital drainage systems – in process of obtaining
- 6. Mobilization
 - a. Up in chair within 2 hours (in PACU)
 - b. First ambulation within 8 hours of extubation
 - c. Head of bed at 30 degrees at all times
 - d. Encourage incentive spirometry use
- 7. Nursing care
 - a. Avoidance of fasting or dehydration
 - b. Daily education, anticipated hospital course, daily reminder of expected discharge date
- 8. Deep venous thrombosis prophylaxis
 - a. 1st line- LWMH 40 mg QHS
 - a. OK to give even in patients with epidural
 - b. 2nd line- SQH 5000u TID
- 9. Fluid management
 - a. LR 50cc/hr, buff capped when tolerating PO, maximum 3L in first 24 hours (including intraop)
 - b. Discontinue maintenance fluids when tolerating clear liquids intake
- 10. Goal discharge
 - a. Minimally invasive surgery- post operative day 2
 - b. Open surgery- post operative day 4

Discharge management

- 1. Discharge Medications
 - a. Tylenol 1,000 mg q8hr
 - b. Ibuprofen 600 mg q6hr
 - c. Gabapentinoid
 - i. Option 1: Lyrica 75 mg (25 mg if >65) BID w/taper protocol
 - ii. Option 2: Gabapentin 300 mg (100 mg if >65) TID w/taper protocol
 - d. Diltiazem PO 30mg q6hr (or dosing required during inpatient stay) w/weekly taper protocol
 - e. Flexeril 5mg TID PRN if required during hospitalization
 - f. Emla cream or lidocaine patch if used during hospitalization
 - g. Opioid management
 - i. If no opioids required on the day prior to discharge, no prescription required
 - ii. If 1-3 opioid pills required on the day prior to discharge, prescribe 15 opioid pills for discharge (either tramadol or oxycodone at dose required during inpatient stay)
 - iii. If 4 or more opioid pills required on the day prior to discharge, prescribe 30 opioid pills for discharge (either tramadol or oxycodone at dose required during inpatient stay)
- 2. Phone call follow up
 - a. Within 48-72 hours
 - b. Assessment for early complications or patient concerns
- 3. Clinic Follow Up
 - a. Routine clinic follow-up in 2 weeks or earlier if indicated