Revista Mexicana de Anestesiología

CONFERENCIAS MAGISTRALES
Vol. 40. Supl. 1 Abril-Junio 2017
pp S340-S344

Enhanced recovery for thoracic surgery

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XLIII Annual Refresher Course in Anesthesiology and Perioperative Medicine.

Enhanced recovery after surgery (ERAS) is a multimodal, multidisciplinary approach to healthcare delivery that includes preoperative preparation, intraoperative care and postoperative recovery. Surgical patients benefit from comprehensive ERAS care through the coordinated efforts of many team members dedicated to optimal outcomes. The care protocols may vary from institution to institution but all share the common commitment to comprehensive care before, during and after surgery. The protocols are evidenced based although, admittedly, locally influenced. The ERAS Society (http://erassociety.org/) maintains a current database, standards, protocols, and a history of the intervention.

ERAS is now endemic in many institutions and across many surgical disciplines. The original study group was formed in 2001 and lead by academic surgeons in Europe[1]. Much of the original work and the majority of publications today involve major abdominal surgical procedures (colectomy, pancreatic surgery), although there are now established protocols in nearly every surgical specialty. The driving force behind all ERAS protocols is the compelling desire to enhanced efficiency, reduce complications, and improve the patient experience[2]. The success of the broad ERAS initiative is linked to demonstrated improvements in all of these areas. Consistently, length of stay is reduced, resource utilization is reduced, complications are lower and patient satisfaction is great when ERAS is employed. Anesthesiologists, Surgeons, and nurses are all involved and play vital roles in ERAS.

ERAS MAIN ELEMENTS OF CARE

Coordinated care is essential at all phases along the ERAS protocol. As may be obvious, the best results are found when all elements are maximized.

Preadmission: The patient should stop smoking and avoid excessive alcohol consumption. There should be nutritional screening and support as indicated. Medical optimization of chronic diseases is necessary.

Preoperative: education of the patient and the caretakers on expectations sets the stage for success. Consumption of a preoperative carbohydrate drink 2 hours before surgery allows optimum storage and utilization of energy stores without increasing aspiration risk. Immediately prior to surgery, the patient should have both thrombosis and infectious prophylaxis. PONV treatment should begin preoperatively with identification of risk and preemptive treatment.

Intraoperative: minimal surgical techniques should be employed whenever feasible. Anesthesia should avoid long-acting narcotics, maintain fluid balance avoiding over or under-hydration. When necessary, vasopressors should be used to support blood pressure as compared to excessive fluid administration. Strict attention to normothermia in the operating room is important. Adjunctive multimodal analgesia is critical and may involved regional nerve blocks. The surgeons should limit the number of drain sites and nasogastric tubes.

Postoperative: early mobilization is a cornerstone of ERAS including on the day of surgery. Other early interventions include intake of fluids and solids (as early as the day of surgery) and removal of all drains and catheters. The intake of protein rich energy drinks can supplement PO fluids and foods. Chewing gum may enhance early return of bowel function. Opioid sparing multimodal analgesics should be continued and PONV treatment continued as necessary. The surgical team should start discharge planning early in the postoperative period.

INITIATING AN ERAS PROTOCOL AND AUDITING OUTCOMES

ERAS care is difficult to organize and complex to administer. Gaining consensus among clinicians and overcoming staffing variability are major hurdles to sustained success. Local

leadership is essential. No team member can orchestrate an ERAS protocol in isolation. Surgeon buy-in is critical and without it the ERAS protocol will fail. Other identified barriers to success are a general resistance to change, a misguided conception that current care is "above average" rendering ERAS unnecessary, a lack of staff resources and time, and poor communication, coordination and collaboration among the caregivers and their respective departments or units. Continuous and ongoing audits of the care process and patient outcomes are essential for long-term success. Many of the ERAS principles are based on a PDSA (Plan-Do-Study-Act) cycle. Reports of implementation success are found in the literature[3]. The ERAS Society also provides tools and guidelines for auditing[4]. The University of North Carolina at Chapel Hill has employed LEAN principles in the initiation of ERAS protocols with success[5].

ERAS AND THORACIC SURGERY

ERAS protocols are now employed in nearly all surgical disciplines and the literature is mounting for the relative success of the various interventions. The most published area involves ERAS and colonic surgery. Many of the principles from this experience are adapted to other disciplines. The unique aspects of thoracic surgery involve the advanced patient morbidities, the invasiveness of the surgery in the thoracic cavity, and the very high incidence of complications and especially pulmonary complications after surgery. The basic protocols are much the same and the reliance on regional anesthesia to include thoracic epidurals or nerve blocks is key. The evidence clearly suggests that ERAS protocols in thoracic surgery reduce complications and duration of stay[6-8].

At the University of North Carolina at Chapel Hill we have found that ERAs reduces time in the PACU and opioid use after thoracic surgery[9]. The unique aspects of our protocol above what has been described above include, Gatorade two hours before surgery, setting a HR and BP range of acceptability, the use of thoracic epidurals and administration of 250 cm^3 5% albumin during epidural placement, ventilator recruitment maneuvers every thirty minutes, extubation in the operating room and the use of multimodal analgesia post operatively to avoid opioids as much as possible.

UNC THORACIC ERAS PROTOCOL AND REFERENCES

Preoperative components

1. *Carbohydrate drink*[1]*:*
   - Instructions provided by clinic nurse navigator during patient's clinic visit
   - Patient will consume clear liquids including Gatorade 2 hours before scheduled surgical time
2. *Baseline blood pressure and ideal body weight assessment*
   - Review patient blood pressure (from clinic visits) and calculate the target blood pressure range
   - Calculate average systolic blood pressure (SBP)
   - Calculate target SBP range: ± 20% Average SBP
   - Ideal body weight is calculated
   - Males: 50 kg + 2.3 kg × each inch above 5 feet
   - Females: 45.5 kg + 2.3 kg × each inch above 5 feet
3. *Pre-operative Patient Education and Wellness Programs*[2-4]
   - Incentive spirometry program: patient provided with an incentive spirometer, is trained by clinic nurse practitioner, and is given educational materials and a log book for recording daily progress[3].
   - Smoking cessation program: referral to smoking cessation program[4]
4. *Preoperative fluid bolus*[5] • -Fluids: 250 cm^3 of 5% albumin should be given during epidural placement.
5. *Mid thoracic epidural*[5-9] • -Anatomic placement: T6-T8 placement for all VATS lobectomy and any open thoracotomy case. ▪ ♉ Epidurals will be placed on a case-by-case basis for VATS wedge
   - Test dose: 3 mL of 1.5% lidocaine with 1:200,000 epinephrine
   - Do not give additional local anesthetic to attempt to achieve a level of analgesia
6. Preoperative multimodal analgesia
   - Acetaminophen 975 mg PO (if liver function tests (LFTs) are not elevated above normal clinical range[10]
   - Pregabalin 100 mg PO[11]
   - Celebrex 200 mg PO

Avoid midazolam for patients > 60 years old

Intraoperative components

1. *Establish blood pressure goals prior to induction*[12]*:* • -Anesthesia team will review the target blood pressure range that was calculated preoperatively by anesthesia provider.
   - Evidence-based recommendations for blood pressure target: maintain systolic blood pressure within 20% systolic baseline[13] with a minimum mean arterial pressure of 55 mmHg[12]
2. *Antibiotic Prophylaxis (per SCIP guidelines)*[14,15]*:* • -Given within 1 hour prior to incision
   - For thoracic surgery: Cefazolin 2 or 3 g IV (per SCIP). ▪ ♉ If beta-lactam allergic, clindamycin 900 mg IV (per SCIP)
3. *VTE Prophylaxis*
   - Heparin 5,000 U SC must be given two hours after epidural placement

- Sequential compression devices will be placed on patient's legs by nursing staff prior to induction of general anesthesia

4. *Anesthetic induction*:
   - Recommend propofol 1-2 mg/kg for induction. However, induction dose of propofol is at discretion of attending anesthesiologist
   - Fentanyl (max dose 2 μg/kg) may be used during the induction of general anesthesia
5. *Epidural Management*[1,6-9]*:*

GOAL is to minimize IV opioids

Special exceptions and dosing considerations may be made for patients who are chronic opioid users

- After metastatic disease has been excluded, recommend hydromorphone 0.4 mg epidural bolus
- Run epidural infusion of 0.25% bupivacaine throughout case (3-6 mL/hour)[1]
- Consult attending anesthesiologist if moderate to severe hypotension develops to evaluate and/or discuss altering epidural infusion rate
- Change the epidural infusion to bupivacaine 0.125%/ hydromorphone 10mcg/ml when closure started[8] ▪ ♉ Special considerations to local only brews on a case-by-case basis

6. *Multimodal Analgesia (for patients who do NOT have an epidural)*

Goal is to minimize IV opioids. IV opioids may be judiciously given.

Special exceptions and dosing considerations may be made for patients who are chronic opioid users

- Exparel (liposomal bupivacaine) will be infiltrated by surgeon (at beginning of case) for all patients without an epidural
- For VATS lobes and open procedures: ◦ ketamine infusion (0.25 mg/kg/h) unless contraindicated
  - ◦ Precedex infusion (0.2-0.3 μg/kg/h) unless contraindicated (consider titrating up to 0.7 μg/kg/h if not using ketamine)

7. *Generalized Fluid Management Principles (all patients)* [12,13,16-18]
   - Albumin based strategy to avoid excess crystalloid administration
   - Intraoperative maintenance fluid based on IDEAL BODY WEIGHT:
     - ▪ Lactated ringers infusion at 2 mL/kg/hour
   - Follow algorithm (can be found on Sharepoint website)
   - Obtain a baseline arterial blood gas prior to incision and then as needed for ongoing evaluation of blood chemistries, hemoglobin, and glucose
8. *Mechanical Ventilation Strategy*[16,19,20]*:* • _Two lung ventilation:
   - ▪ Pressure control ventilation
   - ▪ Tidal volume: 5-10 mL/kg (3-5 mL/kg for end stage lung disease)
   - ▪ FiO_2 0.5
   - ▪ PEEP 5 (end-stage lung disease 3-5 cm H_2O)
   - ▪ Respiratory rate: goal to keep $PaCO_2$ 35-45 mmHg or within 10 mmHg of patient's baseline value
   - ▪ I:E Ratio: 1:2 normal, 1:3-4 obstructive pattern, 1:1 for restrictive pattern
   - One lung ventilation (OLV): ▪ ♉ Pressure control ventilation
   - ▪ Tidal volume: 5-7 mL/kg (6-7 mL/kg for hypoxia or severe hypercapnea)
   - ▪ FiO_2 1.0 for first 10 minutes of OLV. Wean by 0.1 every 5-10 minutes or as tolerated (target saturation > 90%). Discuss with surgeon if/when pulmonary vasculature clipped on surgical side
   - ▪ PEEP 5-8 (end-stage lung disease 3-5 cm H_2O)
   - ▪ Respiratory rate: goal to keep $PaCO_2$ within 10 mmHg of patient's baseline value. Rate 10-15 breaths per min to start (6-8 for end-stage COPD) to keep $PaCO_2$ within 10 mmHg of patient's baseline.
   - ▪ I:E Ratio: 1:2 normal, 1:3-4 obstructive pattern, 1:1 for restrictive pattern
   - Recruitment maneuvers every 30 minutes per evidence-based standards of care
   - ▪ Apply continuous positive airway pressure of 30 cm of water for 10 seconds. Repeat two more times and resume mechanical ventilation
   - Management of hypoxia (oxygen saturation < 90%) on one lung ventilation:
   - ▪ Increase FiO_2 toward 1.0
   - ▪ Recruit maneuvers to dependent (ventilated) lung
   - ▪ Confirm position of lung isolation device with fiberoptic bronchoscopy
   - ▪ Increase PEEP
   - ▪ Ensure adequate cardiac output
   - ▪ CPAP to operative lung (after recruitment)
   - ▪ Ensure adequate oxygen carrying capacity (hemoglobin)
9. *Transfusion Guidelines*[21-23]*:* • _Per American Society of Anesthesiologists practice guidelines and discretion of attending anesthesiologist
   - Discuss transfusion with surgeon before administration of blood products
   - Maintain goal hemoglobin > 7 g/dL. For patients with acute coronary syndrome, maintain hemoglobin > 8 g.dL[23]
   - Discuss transfusion with surgeon before administration of blood product[23]

- Administer 1 unit at a time (unless clinical condition dictates otherwise)[23]

POSTOPERATIVE COMPONENTS

1. *Extubation in OR:* • _If unable to extubate patient, please document clearly in EPIC («Q» note) why patient was not extubated
2. *Anesthesiology PACU Orders:* • _Exception: If epidural is presumed to be non-functional, rescue fentanyl (in excess of 100 ug) may be ordered in PACU until epidural is replaced
   - No long acting opioids. *Special exceptions and dosing considerations may be made for patients who are chronic opioid users*
   - PACU dose of fentanyl limited to 100 µg IV (must change max default dose from 250 µg to 100 µg). *Special exceptions and dosing considerations may be made for patients who are chronic opioid users.*
5. Disposition:
   - PACU for initial recovery phase, then to floor bed or step-down unit (per surgical team)
   - ICU if patient requires post-op mechanical ventilation
4. *Postoperative Pain Management*[24,25]: • -Epidural catheter management per Acute Pain Service (APS) while chest tubes are in place
   - Scheduled multimodal medications per thoracic surgery service:
   - Gabapentin 300 mg PO TID (100 mg TID if age > 70), throughout admission (with prescription to continue until 4 weeks post op)
   - Tylenol 650 mg PO QID throughout admission
   - **For POD 0 only**: scheduled ketorolac 15 mg IV q 8 –OR-- ibuprofen 600 mg PO q 8 × 24 hours
   - **POD 1**: transition scheduled NSAID to ibuprofen 600 mg PO q 6 PRN throughout admission[26]
   - If patient requires a PCA: ▪ It will be ordered and managed by APS if the patient has an epidural
   - It will be ordered and managed by thoracic surgery if the patient does not have an epidural
   - Fentanyl will be first line opioid for PCA
   - Hydromorphone will be second line opioid for PCA
5. *Pulmonary Wellness Strategy:* • -Incentive spirometry instruction and education provided by nursing staff.
   - Patient provided with a bedside log book to record their maximum volume efforts every hour while awake
   - Nurses will verbally encourage and remind patient to use incentive spirometer three times per day
6. *Foley catheter:*
   - Female patients: Foley removed on post-operative day one, unless clinically indicated by surgical team (e.g., for strict monitoring of intake and output)
   - Male patients: Foley removed after removal of epidural catheter, unless clinically indicated by surgical team (e.g., for strict monitoring of intake and output)
7. *Patient activity (e.g., out of hospital bed):* • _Out of bed and ambulation on postoperative day zero (if not contraindicated by surgeon)
   - Daily ambulation at least four times daily
   - Daily ambulation distances recorded by nursing staff in EPIC chart
   - Daily ambulation goals set by patients and written on their hospital white board

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