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Enhanced Recovery via Peripheral Nerve Block for Open Hepatectomy

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Abstract

Background—Enhanced Recovery After Surgery (ERAS) protocols are now commonplace in many fields of surgery but only limited data exists for their use in hepatobiliary surgery. We implemented standardized ERAS protocols for all open hepatectomies and replaced thoracic epidurals with a transversus abdominis plane (TAP) block.

Methods—We performed a retrospective cohort study of all patients undergoing open hepatectomy during the 14 months before and 19 months after implementation of an ERAS protocol at our institution (January 2014–September 2016). Trained abstractors reviewed charts for patient demographics, perioperative details, and healthcare utilization. All nursing-reported Visual Analog Scale pain scores were sampled to identify patients with uncontrolled pain (daily mean score >5). Outcomes included length of stay (LOS), costs and 30-day readmission.

Results—A total of 127 patients (mean age 54.6±13.0 years, 44% female) underwent open liver resection (69 [54%] after ERAS implementation). ERAS protocols were associated with significantly lower rates of ICU admission (47 vs. 13%, $p<0.001$), shorter LOS (median 5.3 vs. 4.3 days, $p=0.007$), and lower median costs (\$3,566 less, $p=0.03$). Readmission remained low throughout the study period (5% pre-ERAS, 4% during ERAS, $p=0.83$). Rates of uncontrolled pain were either the same or better after ERAS implementation through post-operative day #3 (41% pre-ERAS, 23% during ERAS, $p=0.03$).

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Discussion—The use of TAP block for hepatectomy as part of an ERAS protocol is associated with improved quality and cost of care. Surgeons performing liver resections should consider standardization of evidence-based best practices in all patients.

Keywords

enhanced recovery after surgery; hepatectomy; liver resection; peripheral nerve block; transversus abdominis plane block

INTRODUCTION

Standardized and evidence-based perioperative care protocols, widely known as Enhanced Recovery After Surgery (ERAS), have become increasingly common. ERAS protocols were developed in colorectal surgery and have repeatedly been associated with reduction in post-operative length of stay (LOS) and rates of complications.^{1,2} Indeed ERAS protocols now exist for many abdominal operations and have been promoted as a means for improving quality while reducing costs through efforts to quickly return patients to their preoperative physiologic state and diminish the effects of surgical stress.³

Open liver resections are notorious for painful upper abdominal incisions, high complication rates, and hemodynamic instability warranting stays in the intensive care unit (ICU). While there have been limited efforts at adapting ERAS to hepatobiliary (HPB) surgery,^{3,4} this practice is uncommon and warrants further study to identify best-practices. At our institution, we have developed an ERAS protocol for all open hepatectomies including peripheral nerve block in the transversus abdominis plane (TAP) as an alternative to standard thoracic epidural. In this study, we aimed to assess the impact of ERAS for liver surgery and to determine whether this protocol was associated with improved outcomes. We hypothesized that use of ERAS would be associated with shorter LOS and lower costs.

Enhanced Recovery After Surgery (ERAS) Protocols

Through collaboration between anesthesiologists, pain specialists, operating room (OR) nurses, floor nursing teams, and HPB surgeons at our institution, we developed a set of protocols for perioperative care for all open liver resections. Guiding principles for developing these protocols were evidence basis and consensus among participating clinicians. Detailed components of the protocols are listed in Table 1. To address acute nutritional deficiencies associated with surgery, patients receive oral immunonutrition for five days leading up to surgery.^{5,6} In order to limit insulin resistance which occurs during surgery, patients take 8 oz of apple juice the night before and two hours prior to surgery. In the OR, anesthesiologists apply a restrictive fluid strategy, giving weight-based IV fluids and albumin for blood loss with a goal of maintaining low central venous pressure. If possible, patients are extubated and transferred to the floor post-operatively where they receive standardized lab, vital sign, and urine output (UOP) monitoring. On the day of surgery (POD #0), patients begin a clear liquid diet and, with the help of physical therapy, are mobilized to sitting at the edge of the bed. By POD #1 patients are encouraged to walk in the hallway, transition to a regular diet and, if tolerated, begin transition to oral medications. We set goals for discharge with patients as the following: tolerating diet, pain controlled, and ambulating

without assistance. Social workers and pharmacists work with the medical team to coordinate discharge in anticipation of patients going home.

Transversus Abdominis Plane (TAP) Block

An important component of ERAS is the use of regional anesthesia in minimizing the stress of surgery and reducing narcotic use.³ While thoracic epidurals have become a standard form of regional anesthesia for liver resection, there are continued concerns about epidurals related to blood loss, coagulopathy and the need for fluid administration.^{7,8} At our institution, we observed that, for patients with subcostal incisions used in open liver resection, the thoracic epidural was associated with frequent episodes of post-operative hypotension related to sympathetic blockade. Because of this hypotension, patients with high thoracic epidurals often required transfer to ICU for monitoring and holding or discontinuation of the epidural infusion. If the source of hypotension was unclear, these patients may additionally receive IV fluid boluses, blood transfusions and/or vasopressors. In order to achieve good pain control without this unnecessary escalation of care, we sought an alternative nerve block that may be suitable for open hepatectomies. The TAP block is a regional anesthetic technique for blocking the sensory afferents of spinal nerves within the abdominal wall.⁹ When performed in the subcostal location, the TAP block can effectively anesthetize to the level of T7 and has been described for use in upper abdominal surgery.⁹ With the rollout of ERAS protocols, we implemented TAP blocks as a replacement for standard thoracic epidurals.

MATERIALS & METHODS

We performed a retrospective cohort study of all open liver resections at our institution during the 14 months prior to (January 2014–February 2015) and the 19 months following (March 2015–September 2016) implementation of an ERAS protocol including TAP block. This study was approved by the University of Washington Internal Review Board (study #00000901).

Prior to implementing the ERAS protocol, thoracic epidurals were placed by anesthesiologists immediately before the start of the case. After rollout of ERAS, TAP blocks were performed by the surgeons at the end of each case. Patients were treated via one of two block types: 1) after placement of YK5 catheters into the plane between the internal oblique and transversus abdominis the plane was bloused with 20–30 mL bupivacaine 0.25% followed by ropivacaine 0.2% infusion at 5 mL/hour into each or 2) patients received a single dose of liposomal bupivacaine 1.3% (266 mg) diluted to a total volume of 30 ml evenly infiltrated into the transversus abdominis plane.¹⁰

Patient records were reviewed for details of perioperative and postoperative care. Trained abstractors identified patient demographics including age, sex, and American Society of Anesthesiologists (ASA) classification. Operative details were collected including use of epidural and TAP block, type of operation performed (including major (hemihpatectomy and extended hemihpatectomy) and minor liver resections), lesion pathology, total intraoperative IV fluid administration, any blood product transfusions, estimated blood loss, and duration of operation. Post-operatively, we assessed the use of intensive care unit (ICU)

admission during the first three post-operative days (POD). Abstractors also measured utilization of pain control adjuncts to epidural/TAP block including use of patient controlled analgesia (PCA), ketamine infusions, as well as the timing of initiation of oral narcotic and non-narcotic oral analgesics (non-steroidal anti-inflammatory drugs [NSAID] and acetaminophen). Patient-reported pain levels were documented by bedside nurses (on Visual Analog Scale of 0–10) in order to identify patients with uncontrolled pain (defined as average of all pain scores on a given day >5) on each POD up to day #3. In order to determine patient hemodynamic status post-operatively, we documented incidence of hypotension (any systolic blood pressure [SBP] <90 mmHg) on POD #0–3. We also documented any post-operative intravenous (IV) fluid boluses, blood product transfusions, and the use of vasopressors on POD #0–3.

We assessed three main outcomes following surgery: length of stay (LOS), total costs of care (all reimbursed fees and surgical/hospitalization charges), and hospital readmission within 30 days. Costs were adjusted for inflation to 2016 dollars using the Consumer Price Index for Medical Care Services.¹¹ Differences in normally and non-normally distributed continuous variables were assessed using Student's t-tests and Wilcoxon Rank Sum tests, respectively. Differences among categorical variables were assessed using the Chi-squared test. Statistical differences between groups were considered significant if $p < 0.05$. All analyses were performed using commercially available software (Stata 14.2 IC, StataCorp LP, College Station, TX).

RESULTS

A total of 127 patients (mean age 54.6 ± 13.0 years, 44% female, 65% ASA Class III) underwent open liver resection between January 2014 and September 2016 (46% pre-ERAS and 54% after ERAS implementation). The majority of cases were minor resections (65%) and the most common pathology type was secondary liver tumors (59%). Characteristics and operative details are summarized in Table 2. Patients during the pre-ERAS phase had similar characteristics of age, gender, ASA class, extent of resection, and distribution of pathology types as those after rollout of ERAS (all $p > 0.05$). There were no significant differences in case length, intraoperative blood transfusions, estimated blood loss or IV fluid administration before and after ERAS implementation (all $p > 0.05$, Table 2).

With the rollout of ERAS protocols, use of epidurals decreased significantly (86% to 6%, $p < 0.001$) while the majority of patients received TAP block (87%) as peripheral nerve blockade after ERAS implementation (70% ropivacaine infusion, 30% liposomal bupivacaine). Similarly, with ERAS implementation we observed an increase in use of PCAs (78% to 97%, $p < 0.001$). With these changes in pain control modalities, the need for ketamine infusion was stable pre- and post-ERAS (12% vs. 13%, $p = 0.87$) but patients were started on oral narcotics one day earlier after ERAS implementation (median POD#3 vs. POD#2, $p < 0.001$). Figure 1 demonstrates that the proportion of patients with uncontrolled pain (average pain scores >5) pre- and post-ERAS implementation was similar on POD #0 and #1 but by POD #3, the proportion of uncontrolled pain was significantly lower in the ERAS group (23%) compared with prior to ERAS (41%, $p = 0.03$).

Following ERAS implementation, utilization of the ICU for post-operative care decreased significantly (48% to 13%, $p<0.001$). Figure 2 shows that rates of hypotension were significantly lower after ERAS implementation on POD# 0 (50% vs. 23%, $p=0.002$) but that there were no differences in the use of IV fluid boluses, post-operative blood transfusion or vasopressors (all $p>0.05$, Table 3). Throughout the study, patients admitted to the ICU were more likely to receive fluid boluses (73% vs. 30%, $p<0.001$), transfusions (27% vs. 8%, $p=0.004$), and require vasopressors (22% vs. 1%, $p<0.001$). Table 3 demonstrates that median LOS was one day shorter after rollout of the ERAS protocol (5.3 days to 4.3 days, $p=0.007$). After adjusting for inflation, the median total costs for hepatectomy was significantly lower after ERAS implementation (\$28,468 to \$24,912, difference of \$3,566/case, $p=0.03$). Despite a shorter LOS, there was no difference in the rate of hospital readmission within 30 days of discharge (5% vs. 4%, $p=0.83$).

DISCUSSION

After implementation of ERAS protocols at a tertiary care university-based hospital, we report significant reductions in the rate of ICU admissions, LOS, and costs for open liver resections. As part of our novel ERAS pathway, we also observed a trend towards improved post-operative pain control compared with conventional thoracic epidurals used prior to ERAS implementation.

While ERAS protocols have become standard practice in colorectal surgery and other disciplines at many institutions, there are only limited reports of the use of ERAS in HPB surgery. In a recent systematic review, Page and colleagues identified six studies reporting ERAS or “fast-track” protocols for open liver resections (range 91–304 patients).^{3,12–17} Like the protocol described in our study, published ERAS protocols for open hepatectomy focus on four areas of perioperative care: reducing the stress related to laparotomy, minimizing opiate use, limiting blood loss and avoiding transfusion, and changes to perioperative feeding. Among these studies, four reported a reduced LOS associated with ERAS.^{12–14,16} Two studies reported lower rates of post-operative complications associated with ERAS,^{13,16} while three others reporting complication rates did not identify a difference.^{12,14,17} In all six studies, rates of mortality were no different between standard surgery groups and patients receiving care in ERAS programs.

As the focus in ERAS is on rapid recovery, one legitimate concern is that these protocols may lead discharge that is earlier than appropriate.¹⁸ In our study, this possibility appears unlikely as the rate of hospital readmission within 30 days remained low both before (5%) and after (4%) ERAS implementation. This mirrors the findings in four studies reported by Page *et al.*³ Still, further investigation is warranted to determine whether patients are satisfied with earlier discharge to home in this setting.

Another systematic review examined ERAS protocols for patients undergoing both laparoscopic and open hepatectomies.⁴ The meta-analysis of data from eight studies suggested that ERAS was associated not only with shorter LOS but also with earlier functional recovery.^{12–14,16,19–22} In this review, two studies reported ICU utilization which was lower after ERAS.^{12,20} The findings from our study add to this data as we saw the rate of

ICU admission fall from roughly one in two patients before ERAS to less than one in seven patients following ERAS implementation. Rather than a dramatic change in the stability or wellness of patients following liver surgery, we believe this change represents an institutional shift in perspectives away from routine use of ICU services for elective surgery patients. Three studies from China have reported lower costs after ERAS implementation,^{12,22,23} but to our knowledge, our study is the first from the United States to report cost outcomes from ERAS protocols for liver resection (median cost per case was \$3,556 lower after ERAS). While shorter LOS likely contributed to lower costs, simply electing by protocol to transfer patients to the floor service rather than the ICU post-operatively may explain the majority of these savings.

The TAP block has conventionally been used for infraumbilical incisions and only recently has been described for use in subcostal incisions such as those often used in liver resection.^{9,24} While TAP blockade has been established as an alternative to epidurals for pain control in abdominal surgery, data on the comparative effectiveness of these two modalities is inconclusive.^{24–26} Early data published on TAP blockade in HPB surgery are limited to living-related liver donation. Two studies report randomized living donors to TAP block or general anesthesia alone and found that the addition of regional anesthesia was associated with less opiate consumption, lower pain scores, and shorter LOS.^{27,28} In this study, we assessed the utility of TAP blockade from three perspectives: rates of uncontrolled pain, the use of pain adjuncts, and measured rates of hypotension. We found that rates of uncontrolled pain were similar during the pre-ERAS period and after ERAS implementation on the first two post-operative days, but by POD #3 patients in the ERAS group had significantly lower rates of uncontrolled pain (23% vs. 41%, $p=0.03$). It is unlikely that this difference is due to the TAP block but instead reflects patients beginning oral narcotics earlier (median POD #2 vs. #3, $p<0.001$) as prescribed by our ERAS protocol. This finding may also reflect the increase in PCA utilization with rollout of ERAS (78% to 97%, $p<0.001$). Additionally, with a shift from epidural to TAP block, we found no change in the number of patients requiring ketamine infusions, a modality typically reserved for patients with severe uncontrolled pain. While comparative effectiveness of these modalities would best be studied in a prospective randomized setting, we conclude that pain control with TAP blockade was at least no worse than standard thoracic epidural. Because major hepatectomy is associated with a decrease in ropivacaine clearance by >50% after TAP injection,²⁹ future efforts at TAP blockade in liver resection should include close collaboration with anesthesiologists knowledgeable in regional anesthesia. Further investigation of the benefits of preventative anesthesia in liver resection is also warranted.³⁰

By applying TAP blocks, we aimed to avoid the iatrogenic hypotension associated with high thoracic epidurals. In this study, we found lower rates of hypotension on POD#0 in the ERAS group (23% vs. 50%, $p=0.002$). This findings was not accompanied by a change in the rate of post-operative transfusion, IV fluid bolus, or vasopressor use. This finding would be expected if most episodes of hypotension prior to ERAS were due to sympathetic blockade by epidural analgesia which is often reversible by discontinuation of the epidural infusion. Another possible explanation for fewer hypotensive episodes after ERAS implementation is the lower use of ICU care, a setting where blood pressure is checked more frequently, thereby increasing the probability of a low reading. Regardless of the underlying

cause, we feel this reduction in post-operative hypotension with ERAS has contributed to fewer unnecessary escalations of care.

There are important limitations to this study that warrant discussion. First, we did not measure rates of post-operative complications such as infection, bile leak, or liver failure. Because published ERAS protocols in liver surgery have previously reported mixed results in rates of post-operative complications, our hypotheses did not include reductions in these adverse events. Future work should include this assessment of safety. Second, TAP blockade has been associated with a 30% rate of therapeutic failure.²⁶ Similarly, in this series a minority of patients with TAP catheters experienced leakage of the anesthetic solution. This factor led surgical teams to favor the use of one-time TAP blockade with long-acting liposomal bupivacaine over continuous infusion via catheters. Due to small sample sizes, assessing the comparative effectiveness of TAP block via continuous ropivacaine infusion versus liposomal bupivacaine was not achievable. Third, while our study identified differences in both LOS and cost associated with ERAS implementation, it is difficult to attribute outcomes to specific components of the protocol. While likely multifactorial, we suspect that reductions in ICU utilization may explain the majority of cost-savings. Fourth, the preference of HPB surgeons at our institution is for subcostal incisions for open liver resection. It is unclear whether these findings will be generalizable to surgeons who use midline incisions for hepatectomy. Lastly, in assessing processes of care, it is important to consider the influence of individual practitioners. While we did not evaluate this factor, our institution saw no turnover of HPB surgical staff or change in their practice patterns during the period of the study and therefore we believe that any effect at the surgeon-level would be minimal.

CONCLUSIONS

In this study, we report the results of standardized best practices as part of an ERAS program for open liver resection in concert with a novel pain control strategy via TAP blockade, as a viable alternative to thoracic epidural pain management. After implementation, we observed significant reductions in ICU utilization, LOS, and costs with pain control that was at least as good as conventional thoracic epidural. Through multi-disciplinary collaboration, ERAS protocols can be safely implemented with measurable benefits in quality of care.

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ABBREVIATIONS

ASA	American Society of Anesthesiologists
CVP	central venous pressure
ERAS	enhanced recovery after surgery

HPB	hepatobiliary
ICU	intensive care unit
IV	intravenous
LOS	length of stay
NSAID	non-steroidal anti-inflammatory drug
OR	operating room
PACU	post-anesthesia care unit
PCA	patient controlled analgesia
POD	post-operative day
SBP	systolic blood pressure
SD	standard deviation
TAP	transversus abdominis plane UOP
	urine output

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Figure 1.

Proportion of patients with uncontrolled pain (average of day's pain scores >5) on post-operative days (POD) 0 through 3 in the pre-ERAS and ERAS groups

Figure 2. Proportion of patients with hypotension (SBP < 90 mmHg) on post-operative days (POD) 0 through 3 in the pre-ERAS and ERAS groups

Table 1**Enhanced Recovery After Surgery (ERAS) pathway components for open liver resection**

Prior to surgery	Discuss care plan with patients and set expectations of post-op course
	Send enoxaparin prescription to discharge pharmacy
	Schedule post-op follow-up appointment
	Immunonutrition ×5 days preop
	8 oz apple juice on night before and 2 hours prior to surgery
	Subcutaneous heparin and sequential compression devices prior to case start
	Obtain preop baseline glucose
Intraoperatively	Place arterial line, two peripheral IVs, and foley
	Heating mattress and over-body warmers
	IV antibiotics on induction
	Restrictive fluid strategy: 500mL bolus LR then 2 mL/kg/hr, goal CVP <5mmHg
	For blood loss up to 1500 mL, give albumin 1:1
	For blood loss >1500 mL, notify attending anesthesiologist, send hemostasis panel & ABG
	For hypotension, administer phenylephrine 0.8 mcg/kg/min, consider mannitol 50 mL/hr to stimulate UOP
	Monitor glucose
	TAP block:
	20–30mL bupivacaine 0.25%
PACU	place two YK5 catheters and infuse 5mL/hr ropivacaine 0.2% into each
	OR
	30mL liposomal bupivacaine 1.3% (266mg)
	Extubate if possible
	Start hydromorphone PCA
	Weight based maintenance fluids: D5 LR 1mL/kg/hr, target UOP 0.3–0.5mL/kg/hr
	Draw coags & Hct q8 hours:
	Give vitamin K 10mg IV ×3 days if INR >1.6
	Give FFP if INR >1.9 or concern for hemorrhage
POD #0	If extubated, transfer to surgery floor
	Check UOP & vitals q1 hours ×2, q2 hours ×2, then q8 hours
	Clear liquid diet
	Incentive spirometry 10× per hour when awake
POD #1	Physical & occupational therapy evaluate patient, mobilize to edge of bed
	Advance to regular diet, patient is out of bed for all meals
	Out of bed ×3–4 times, goal walk 9 laps in hallway
	Stop IV fluids if tolerating diet
	Begin docusate 200mg PO BID
	Begin subcutaneous heparin daily if INR <1.5
POD #2	Begin acetaminophen 650mg PO q6 hours if Tbili <2.5 & AST/ALT <3× normal
	Begin ketorolac 15mg IV q6 hours if coags normal, INR <1.6, & no concern for bleeding
	If YK5 TAP catheters in place, stop ropivacaine infusion and
	Stop PCA and transition to oral narcotics

	Stop ketorolac and begin ibuprofen 600mg q6 hours if CrCl>60 and coags are normal
	Remove foley
	Pharmacist teaches patient enoxaparin self-administration
	Discontinue labs if stable
POD #3-5	Out of bed 3-4 times, goal walk 18 laps in hallway
	Suppository if no bowel movement
	Shower if all catheters are out
	Social work visit on POD#3 to coordinate discharge
	Order medical equipment for home use as needed
Day of Discharge	Goals for discharge: tolerating diet, pain controlled, return of bowel function, ambulating independently
	Shower and dress in home clothing by 9am
	Confirm patient education is complete and patient has follow-up appointment
	Goal discharge by 11am
	Enoxaparin subcutaneous for 28 days following discharge

ABG – arterial blood gas
 CVP – central venous pressure
 ERAS – enhanced recovery after surgery
 INR – international normalized ratio
 IV – intravenous
 LR – lactated Ringer's
 PACU – post-anesthesia care unit
 POD – post-operative day
 q – every
 TAP – transversus abdominis plane block

Table 2

Patient characteristics and operative details of patients undergoing open liver resection before and after implementation of Enhanced Recovery After Surgery (ERAS)

	All Patients (n=127)	Pre-ERAS (n=58)	ERAS (n=69)	p- value
Mean age, years (SD)	54.6 (13.0)	52.9 (12.1)	56.0 (13.6)	0.19
Female, n (%)	56 (44)	24 (41)	32 (46)	0.57
ASA class, n (%)				0.41
I	2 (2)	1 (2)	1 (1)	
II	33 (26)	11 (19)	22 (32)	
III	83 (65)	41 (71)	42 (61)	
IV	9 (7)	5 (9)	4 (6)	
Major resection, n (%)	44 (35)	18 (31)	26 (38)	0.43
Pathology type, n (%)				0.10
Primary HPB	44 (35)	16 (28)	28 (41)	
Secondary malignancy	75 (59)	40 (69)	35 (51)	
Benign	8 (6)	2 (3)	6 (9)	
Median intraoperative fluids, mL (IQR)	4139 (3007–5271)	4469 (3015–6009)	4025 (2986–4669)	0.07
Median estimated blood loss, mL (IQR)	750 (250–1500)	750 (400–1400)	600 (250–1550)	0.36
Intraoperative blood transfusion, n (%)	37 (29)	20 (34)	17 (25)	0.22
Median case length, mins (IQR)	253 (201–341)	253 (210–349)	253 (199–340)	0.58
Perioperative pain control, n (%)				
Epidural	54 (43)	50 (86)	4 (6)	<0.001
TAP block	60 (47)	0 (0)	60 (87)	<0.001

HPB - hepatobiliary

IQR – interquartile range

SD – standard deviation

TAP – transversus abdominis plane

Table 3

Post-operative utilization and outcomes before and after implementation of Enhanced Recovery after Surgery (ERAS)

	All Patients (n=127)	Pre-ERAS (n=58)	ERAS (n=69)	p-value
ICU admission, n (%)	37 (29)	28 (48)	9 (13)	<0.001
Median ICU stay[*], days (IQR)	1 (1–2)	1 (1–2.5)	1 (1–2)	0.79
Pain control adjuncts, n (%)				
PCA use	112 (88)	45 (78)	67 (97)	<0.001
Ketamine use	16 (13)	7 (12)	9 (13)	0.87
Median POD starting PO analgesic, # IQR	2 (1–4)	2 (1–4)	2 (1–4)	0.16
Median POD starting PO narcotic, # IQR	3 (2–3)	3 (3–4)	2 (2–3)	<0.001
Postop blood pressure adjuncts, n (%)				
RBC transfusion	17 (13)	8 (14)	9 (13)	0.90
IV fluid bolus	54 (43)	24 (41)	30 (43)	0.81
Vasopressors	9 (7)	4 (7)	5 (7)	0.94
Outcomes				
Median length of stay, days (IQR)	4.4 (4.1–6.2)	5.3 (4.3–6.3)	4.3 (3.3–5.4)	0.007
30-day readmission, n (%)	6 (5)	3 (5)	3 (4)	0.83
Median total costs ^{***} , USD (IQR)	\$26,144 (\$20,839–33,769)	\$28,468 (\$22,609–36,095)	\$24,912 (\$19,660–29,665)	0.03

* Among patients admitted to the ICU

** Adjusted for inflation to 2016 dollars

ERAS – Enhanced Recovery After Surgery

ICU – intensive care unit

IQR – interquartile range

PCA – patient controlled analgesia

USD – United States Dollars