Enhanced Recovery With Paravertebral and Transversus Abdominis Plane Blocks in Microvascular Breast Reconstruction

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ABSTRACT

PURPOSE: We have shown previously that a preoperative paravertebral nerve block is associated with improved postoperative recovery in microvascular breast reconstruction. The purpose of this study was to compare the outcomes of a complete enhanced recovery after surgery (ERAS) protocol with complete regional anesthesia coverage to our traditional care with paravertebral block.

PATIENTS AND METHODS: This was a retrospective cohort study of 83 patients who underwent autologous breast reconstruction by T.M.M. between May 2014 and February 2018 at a tertiary academic center. Patients in the ERAS group were additionally administered acetaminophen, non-steroidal anti-inflammatory drugs (NSAIDs), gabapentin, a transversus abdominis plane block (liposomal or plain bupivacaine), and primarily oral opioids postoperatively. The patients were mobilized earlier with more rapid diet progression. All patients received a preoperative paravertebral block.

RESULTS: Forty-four patients in the ERAS cohort were compared with 39 retrospective controls. The 2 groups were similar with respect to demographics and comorbidities. The ERAS cohort required significantly less opioids (291 vs 707 mg oral morphine equivalent, $P < .0001$) with unchanged postoperative pain scores and a shorter time to oral only opioid use (16.0 vs 78.2 hours, $P < .0001$). Median length of stay (3.20 vs 4.62, $P < .0001$) and time to independent ambulation (1.86 vs 2.88, $P < .0001$) were also significantly decreased in the ERAS cohort. Liposomal bupivacaine use did not significantly affect the results ($P \geqslant .2$).

CONCLUSIONS: Implementation of a robust enhanced recovery protocol with complete regional anesthesia coverage was associated with significantly decreased opioid use despite unchanged pain scores, with improved markers of recovery including length of stay, time to oral only narcotics, and time to independent ambulation.

KEYWORDS: Microvascular breast reconstruction, enhanced recovery, multimodal analgesia

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Introduction

Autologous microvascular breast reconstruction is potentially associated with superior cosmetic results, patient satisfaction, and patient-reported quality of life relative to simpler methods.[1,2] However, it is historically associated with a longer initial recovery time and substantial postoperative pain.[3,4] In the past IV patient-controlled opioids were the mainstay of pain treatment. Our patients were kept in nothing by mouth (NPO) status, had a urinary catheter, and remained on bedrest for over 24 hours after surgery. These conservative practices were adopted to maximize safety, but recent studies in this patient population have shown them to be associated with delayed recovery.[5-12]

In May 2014, we added regional anesthesia in the form of a T3 paravertebral block as a method to improve pain control and postoperative outcomes after abdominally based autologous microvascular breast reconstruction. This single intervention was associated with improved outcomes including less acute pain, a more rapid transition to oral opioids, and decreased hospital stay by a full day.[13] Less than 2 years later we adopted a full enhanced recovery protocol (enhanced recovery after surgery [ERAS]) adapted from the University of Toronto's experience with pedicled flap reconstruction.[11] This was done to both improve outcomes and also standardize treatment as part of a randomized controlled trial on liposomal bupivacaine. The results of the trial did not support any benefits to using liposomal bupivacaine as part of an intraoperative transversus abdominis plane (TAP) block, but it did not directly examine the effects of the enhanced recovery protocol.[14] This study compares the effects of the ERAS protocol (June 2016-February 2018) to our traditional care with the addition of a paravertebral nerve block (May 2014-August 2015). We hypothesized that the ERAS cohort would require less opioid pain medications and have improved markers of recovery.

Patients and Methods

Study design and population

This was a retrospective, single-surgeon, cohort study of 2 groups of patients who underwent abdominally based autologous breast reconstruction by the senior author (T.M.M.) between May 2014 and February 2018. It was approved by the Institutional Review Board (#201601064) at Washington University in St. Louis. All patients underwent an abdominally based autologous microvascular free flap breast reconstruction at Barnes Jewish Hospital supplemented by a T3 thoracic paravertebral nerve block. The ERAS cohort was managed using a complete enhanced recovery protocol implemented as part of the "Analgesic Effects of Liposomal Bupivacaine Versus Bupivacaine Hydrochloride Administered as a Transversus Abdominis Plane Block After Abdominally Based Autologous Microvascular Breast Reconstruction—A Prospective, Single-Blinded, Randomized Control Trial."[14] Cases completed between August 7, 2015, and June 10, 2016, were excluded due to phased implementation of the complete enhanced recovery protocol. STROBE guidelines were adhered to during all phases of this research.

Surgical techniques

All patients underwent immediate or delayed autologous microvascular reconstruction with muscle-sparing transverse rectus abdominis myocutaneous (ms-TRAM), deep inferior epigastric perforator (DIEP), or superficial inferior epigastric artery (SIEA) flaps. Donor-site fascia was closed either primarily or with mesh reinforcement at the discretion of T.M.M.

Historical controls (May 2014–August 2015)

This cohort of patients was managed traditionally with the goal of minimizing potential damage to the flap in the early postoperative period and allowing for rapid safe return to the operating room if necessary (Supplemental Figure 1). Patients were kept in NPO status for 36 hours after surgery on bedrest with a urinary catheter and pain managed primarily by hydromorphone patient-controlled analgesia (PCA). Ambulation to chair was allowed and the diet was advanced to clear liquids on the second postoperative day. The urinary catheter and PCA were discontinued as tolerated on postoperative day 3. Preemptive analgesia consisted of preoperative ultrasound-guided parasagittal approach T3 paravertebral blocks with 15 mL of 0.5% bupivacaine injected per side for analgesia to the chest wound and subcutaneous infiltration of bupivacaine to the abdominal wound at the end of the case. Some of the traditionally accepted ERAS components were already in place during this cohort including preadmission counseling on expectations, venous thromboembolism prophylaxis, antimicrobial prophylaxis, nausea and vomiting prophylaxis, flap monitoring, a nerve block to the breast wound in the form of a paravertebral block, and standardized discharge criteria. The benefits of the paravertebral block in this patient population were studied previously.[13]

ERAS care (June 2016–February 2018)

Our ERAS protocol includes almost all expected major components including preadmission counseling on expectations, reduced perioperative fasting, venous thromboembolism prophylaxis, antimicrobial prophylaxis, nausea and vomiting prophylaxis, multimodal analgesia to decrease opioid requirements, nerve blocks to all surgical wounds, early removal of lines, tubes, and drains, early feeding, early mobilization, flap monitoring, and standardized discharge criteria (Figure 1, Supplemental Figure 2).[14,15] Intraoperative intravenous fluid administration was managed traditionally per the discretion of the anesthesia team. Their long-standing goals for these cases are to administer crystalloid or colloid as needed to maintain mean arterial pressure greater than 80% of preoperative values and greater than 60 mm Hg without pressor administration. We believe that reduced IV fluid use could be associated with unacceptably low intraoperative blood pressure based on our prior experience with attempting to reduce intraoperative IV fluid in this patient population as well as recently published research.[16]

A complex standardized multimodal analgesia protocol was adopted with the goal of decreasing postoperative pain and patient request for opioid use. In addition to preoperative paravertebral blocks, scheduled acetaminophen 1000 mg QID, celecoxib 200 mg BID, oxycontin 10 mg BID, and gabapentin 300 mg QHS were administered pre- and postoperatively. An intraoperative TAP block was administered with either 266 mg of liposomal bupivacaine or 75 mg of conventional bupivacaine under direct visualization to the T6-L1 intercostal levels immediately prior to closure of the transverse abdominal incision as further described in the liposomal bupivacaine trial.[14] We have previously shown there were no differences regarding pain control or any major outcome between liposomal bupivacaine or conventional bupivacaine in this cohort.[14] On postoperative day (POD) zero, 1 mg of hydromorphone IV was made available every hour for rescue analgesia. Beginning with POD 1, 5 to 10 mg of oral oxycodone was offered every 3 hours as well as 0.5 mg of hydromorphone IV every hour as needed for breakthrough pain. Nausea was preemptively controlled with scopolamine patches, intraoperative dexamethasone, and ondansetron. Patients were encouraged to get out of bed to a chair on POD 1, ambulate with assistance on POD 2, and ambulate independently on POD 3. The goal discharge date was the morning of POD 3. Discharge criteria included reassuring flap exams by physician staff, adequate pain control on oral medications, ability to urinate spontaneously and to ambulate independently with waist flexed if needed to minimize tension, as well as tolerance of preoperative diet with return of bowel function.

	ERAS	Traditional
HYDRATION/ DIET	– 12oz Water or carbohydrate drink at 5AM before surgery – NPO until POD 1 – Saline lock IV POD 2	– NPO after midnight before surgery – NPO until POD 2 – Continuous IV fluids until POD 4
ANALGESIA	– T3 Paravertebral block preoperatively – Transversus abdominis plane block before extubation – No PCA – Acetaminophen + NSAID + gabapentin + Oxycontin scheduled before and after surgery until discharge – PRN Oxycodone and hydromorphone	– T3 Paravertebral block preoperatively – PCA until POD 3 – Hydrocodone/acetaminophen POD3
OTHER MEDICATIONS	– Antibiotic – Dexamethasone + ondansetron intraoperatively – Ondansetron + enoxaparin + Docusate postoperatively	– Antibiotic – Dexamethasone + Ondansetron intraoperatively – Ondansetron + Enoxaparin + Docusate postoperatively
FLAP CARE	– Flap checks Q1 hr POD0, Q2h POD1, Q4h POD 3	– Flap checks Q1 hr POD0, Q2h POD1, Q4h POD 3
URINARY CATHETER	– Removed POD 1	– Removed POD 3
AMBULATION	– Out of bed POD 1	– Out of bed POD 2

Figure 1. Comparison of ERAS to traditional care.
ERAS indicates enhanced recovery after surgery; NPO, nothing by mouth; NSAID, non-steroidal anti-inflammatory drug; PCA, patient-controlled analgesia; POD, postoperative day; PRN, as needed; Q, dosed every.

Data collection and outcome measures

Baseline patient demographic and clinical variables included age, race, body mass index (BMI), American Society of Anesthesiology (ASA) classification, preoperative opioid use, and comorbidities. Baseline data was pulled directly from a detailed history taken by the Center for Preoperative Assessment and Planning at Barnes Jewish Hospital. Pathologic variables included breast cancer side, history of chemotherapy, radiation, and mastectomy type. Reconstructive variables included laterality, timing of reconstruction, flap type, and mode of abdominal fascia closure. Complications and return trips to the operating room were also tabulated.

The primary outcome of this review is the total intra- and postoperative opioid consumption calculated in oral morphine equivalents. Secondary outcome measures are patient-reported numerical rating scale (NRS) pain scores at 2, 12, 24, 48, and 72 hours postoperatively, duration of admission, amount of antiemetic use, time to urinary catheter removal, time to independent ambulation, and time to oral only narcotics.

Statistical analyses

Our baseline data and demographics were compared with Fisher exact test, Student's *t* test, or Mann-Whitney *U* test when appropriate. Normality was assessed using the Shapiro-Wilk test and QQ plots (SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp). Our primary outcome and most secondary outcomes were analyzed with the Mann-Whitney *U* test due to skewed results distributions. To better characterize the duration of admission data, a Kaplan-Meier analysis was also performed (Graphpad Prism 7 for Windows San Diego, CA). No adjustments were made due to near-perfect matching of baseline characteristics that are known to affect postoperative pain.

Results

Patient population

From June 2016 through March 2018, 70 patients who underwent abdominally based microvascular breast reconstruction after mastectomy were enrolled in "The Analgesic Effects of Liposomal Bupivacaine Versus Bupivacaine Hydrochloride Administered as a Transversus Abdominis Plane Block After Abdominally Based Autologous Microvascular Breast Reconstruction—A Prospective, Single-Blinded, Randomized Control Trial." Forty-four patients, or 22 in each group, completed the study. These patients comprise the ERAS cohort of this study. Ten patients had their surgeries scheduled after the trial closed. Eight were deemed ineligible because they were later found to take preoperative narcotics daily, deviated significantly from the enhanced recovery protocol, or developed recurrent disease prior to surgery. Four patients withdrew their consent and another 4 patients had missing data. In total, 83 patients are included in this study. A total of 39 patients who underwent abdominally based microvascular breast reconstruction after mastectomy between May 2014 and August 2015 were consecutively reviewed as retrospective controls. No

Table 1. Baseline demographic and clinical variables.

	HISTORICAL (N = 39)		ERAS (N = 44)		*P*
Age	49	(9.0)	49	(9.5)	.82
Race					
White	32	(82%)	39	(89%)	.53
Non-white	7	(18%)	5	(11%)	
Weight (kg)	78.8	(13.4)	78.6	(13.5)	.94
BMI	29.2	(4.8)	28.6	(4.5)	.59
ASA Score (IQR)	2	(0)	2	(0)	.49
Home opioid use preoperatively	6	(15%)	5	(11%)	.75
DM	4	(10%)	1	(2%)	.18
GERD	11	(28%)	15	(34%)	.64
HTN	10	(26%)	5	(11%)	.15
Vascular disease	3	(8%)	0	(0%)	.10
Valvular disease	3	(8%)	2	(4%)	.66
CAD	0	(0%)	0	(0%)	—
Arrhythmia	0	(0%)	1	(2%)	1.00
CHF	0	(0%)	0	(0%)	—
Asthma or COPD	6	(15%)	5	(11%)	.75
OSA	2	(5%)	5	(11%)	.44
CKD	0	(0%)	1	(2%)	1.00
Stroke history	0	(0%)	0	(0%)	—
PONV history	11	(28.2)	13	(29.5)	1.00
Chemotherapy history	26	(67%)	34	(77%)	.33
Radiation history	23	(59%)	27	(61%)	1.00
Breast cancer side					
Right	19	(48%)	22	(50%)	.58
Left	13	(33%)	10	(23%)	
Bilateral	6	(15%)	8	(18%)	
None	1	(3%)	4	(9%)	
Breast cancer surgery side					
Right	10	(26%)	14	(32%)	.16
Left	7	(18%)	2	(4%)	
Bilateral	22	(56%)	28	(64%)	

Abbreviations: ASA, American Society of Anesthesiology; BMI, body mass index; CAD, coronary artery disease; CHF, congestive heart failure; OSA, obstructive sleep apnea; CKD, chronic kidney disease; PONV, postoperative nauesa and vomiting; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; ERAS, enhanced recovery after surgery; GERD, gastroesophageal reflux disease; HTN, hypertension; IQR, interquartile range; SD, standard deviation.
Values are presented as mean (SD), median (IQR), or n (n%).

patients were excluded. There were no missing data for any outcome measures on included patients.

Baseline characteristics

The 2 groups were similar with respect to age, race, ASA score, BMI, preoperative opioid use, comorbidities, and breast cancer laterality (Table 1). There was also no statistically significant difference between the 2 groups regarding reconstruction timing, donor type (ie, DIEP/ms-TRAM/SIEA), donor-site closure method, case duration, or complications (Table 2). Complications were recorded if there was a need for bedside intervention or return to the operating room. Despite not deliberately matching the groups, the 2 cohorts are effectively matched for all risk factors for increased postoperative pain (age, BMI, ASA score, opioid use, case duration, chemotherapy, and radiation history).

Table 2. Baseline reconstructive variables.

	HISTORICAL (N=39)		ERAS (N=44)		*P*
Reconstruction side					
Right	10	(26%)	14	(32%)	.16
Left	7	(18%)	2	(4%)	
Bilateral	22	(56%)	28	(64%)	
Delayed reconstruction	33	(85%)	36	(82%)	.70
Right abdomen donor type					
DIEP	24	(62%)	26	(59%)	1.00
MS-TRAM	8	(20%)	9	(20%)	
SIEA	1	(3%)	1	(2%)	
TRAM	0	(0%)	1	(2%)	
Left only	6	(15%)	7	(16%)	
Left abdomen donor type					
DIEP	23	(59%)	23	(52%)	.51
MS-TRAM	5	(13%)	10	(23%)	
SIEA	0	(0%)	2	(4%)	
TRAM	1	(3%)	1	(3%)	
Right only	10	(26%)	8	(18%)	
Right abdomen closure					
Primary closure	27	(69%)	26	(59%)	.57
Mesh	5	(13%)	9	(20%)	
No fascial closure necessary	7	(18%)	9	(20%)	
Left abdomen Closure					
Primary closure	18	(46%)	24	(54%)	.77
Mesh	11	(28%)	10	(23%)	
No fascial closure necessary	10	(26%)	10	(23%)	
Anesthesia case duration (hours)	9.8	(2.0)	9.4	(1.7)	.33
Surgical complications					
Venous congestion	1	(3%)	2	(4%)	1.00
Partial flap loss/flap necrosis	2	(5%)	2	(4%)	1.00
Arterial insufficiency	0	(0%)	2	(4%)	.50
Abdominal wound dehiscence	4	(10%)	0	(0%)	.05
Donor-site seroma	1	(3%)	0	(0%)	.47
Donor-site hematoma	0	(0%)	1	(2%)	1.00
Complete flap loss	0	(0%)	0	(0%)	1.00
Breast hematoma	0	(0%)	0	(0%)	1.00
Abdominal cellulitis	1	(3%)	0	(0%)	1.00
Total	9	(23%)	7	(16%)	.58

Abbreviations: DIEP, deep inferior epigastric perforator; ERAS, enhanced recovery after surgery; MS-TRAM, muscle-sparing transverse rectus abdominis muscle; SIEA, superficial inferior epigastric artery; TRAM, transverse rectus abdominis muscle.
Values are presented as mean (SD) or n (n%).

Table 3. Outcomes.

	HISTORICAL (N = 39)		ERAS (N = 44)		*P*
Opioid usage (oral morphine equivalents, mg)					
Intraoperative	145	(70)	102.5	(64)	.001
PACU and Floor	525	(370)	161	(166)	<.0001
PACU and Floor per day	129	(62)	62	(52)	<.0001
Total	707	(430)	291	(220)	<.0001
Pain scores					
2 hours	3	(5)	2	(5)	.64
12 hours	2	(5)	0.5	(3)	
24 hours	4	(5)	2	(5)	
48 hours	3	(3)	2	(4)	
72 hours	2	(4)	1.5	(4)	
Time to oral only narcotics (hours)	78.2	(29)	16.0	(16)	<.0001
Duration of admission	4.62	(1.0)	3.20	(1.0)	<.0001
Duration of catheter	3.24	(0.9)	1.05	(0.8)	<.0001
Time to ambulation	2.88	(1.1)	1.86	(0.9)	<.0001
Antiemetic doses					
PACU	0	(0)	0	(0)	.60
Floor	0	(2)	0	(3)	.72
Total	0	(2)	0	(3)	.92

Abbreviations: ANOVA, analysis of variance; ERAS, enhanced recovery after surgery; IQR, interquartile range; PACU, postoperative acute care unit.
Values are presented as median (IQR).
Mann-Whitney *U* or General Linear Model Repeated-Measures ANOVA (Pilal's Trace) used where appropriate.
P < .007 is considered significant based on 7 concurrent comparisons (Bonferroni).

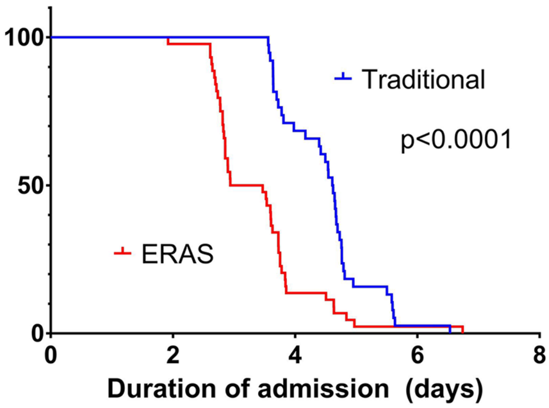

Figure 2. Duration of admission.
ERAS indicates enhanced recovery after surgery.

Outcomes

The median total opioid consumption in the ERAS group (291 mg) was significantly decreased when compared with historical controls (707 mg, $P < .0001$) (Table 3). Opioid use also revealed consistently significant between-group differences. This effect was not associated with time when a segmental regression analysis was performed for the historical and ERAS periods ($r^2 = 0.006$, $P = .32$, $r^2 = 0.009$, $P = .27$). Despite markedly decreased opioid usage, pain scores were not significantly different between groups. As one would expect with a protocol that discourages IV PCA usage, time to oral only narcotic use was significantly decreased by over 2 days (78.2 vs 16.0 hours, $P < .0001$). Median total opioid use was significantly higher in patients with delayed reconstruction (443 vs 339 mg, $P = .045$). There were no other significant differences regarding reconstruction timing.

The ERAS protocol's attempts to encourage ambulation, remove the urinary catheter earlier, and support earlier discharge home were successful. Patients were able to independently ambulate 1 full day earlier as the protocol suggested (1.86 vs 2.88 days, $P < .0001$). The duration of the urinary catheter was significantly reduced from 3.24 days to 1.05 days ($P < .0001$). Patients in the ERAS group were able to be discharged more than 1 full day earlier (3.20 vs 4.62 days, $P < .0001$). A Kaplan-Meier analysis best characterizes this (Figure 2, $P < .0001$). Liposomal bupivacaine or plain bupivacaine usage did not affect any of the above results ($P \geqslant .2$).[14] There was no significant difference with respect to antiemetic usage. This study was not powered to comment on differences in complication rates. There were no complications attributed to the paravertebral or TAP blocks.

Discussion

The results of this study demonstrate that implementation of the ERAS protocol was associated with unchanged pain scores despite significantly reduced opioid consumption. Efforts to improve the pace of recovery were successful with greater than 1 day decreases in time to oral only narcotics, duration of urinary catheter, time to independent ambulation, and duration of admission. These results are consistent with the success of other ERAS protocols previously implemented in breast reconstruction surgery. Our patients' median NRS pain scores (0.5-2) and median 3.2 day duration of admission were similar to the lowest reported by other comparable studies.[5-7,9,12,17] A recent nationwide review by Billig of the national inpatient sample showed a median length of stay of 4 days (interquartile range [IQR], 3-5).[18]

We believe that analgesia to the chest wound is required for maximum benefit. Four other ERAS protocols without regional analgesia to the chest reported potentially higher median durations of admission: Bonde (6.2 days), Astanahe (4.8 days), Alfonso (4.0 days), and Bardorf (3.9 days).[5-7,17] Kouzantis et al[12] presented a protocol with a median duration of admission of 3.0 days without regional anesthesia to the chest wall, but used IV ketamine, methadone, and a lidocaine infusion started intraoperatively and continued for 24 hours postoperatively. These additional nonopioid methods of pain control may be an alternative to nerve block for chest wall pain. However, a lidocaine infusion with a bolus shortly after a TAP block as administered Kouzantis' study could potentially increase the risk of intraoperative local anesthetic toxicity. It may be safer to delay initiation of the lidocaine infusion protocol for 4 hours after the TAP block or avoid the initial bolus. Similarly, it is important to separate abdominal and chest wall blocks by the most time possible to allow for higher dosage of local anesthetic without putting the patient at risk for local anesthetic toxicity. This is why in our protocol the paravertebral block is administered preoperatively and the abdominal TAP block is placed at the end of the case, over 6 hours apart. After 6 hours, the plasma level of local anesthetic is reduced by over 50%.[19]

Other potential alternatives to the paravertebral block for analgesia could include intercostal, erector spinae, or serratus anterior plane blocks.[20-22] We perform paravertebral analgesia due to its well described benefits in the literature and availability of an experienced dedicated regional anesthesia team to perform the nerve block preoperatively. Paravertebral blocks, IV lidocaine infusions, and continuous local anesthetic wound infusions have been associated with decreased acute and chronic postoperative pain in multiple breast surgery studies.[23] Of these, paravertebral blocks are the only non-continuous option. They also have the advantage of not affecting intraoperative blood pressure.[15]

It is our opinion that ERAS in microvascular breast reconstruction should be the standard of care. Our study is consistent with a recent meta-analysis that found significant improvement in opioid use and length of stay with no increase in complications.[24,25] With paravertebral as well as TAP analgesia, our protocol was unique in accomplishing this without continuous infusions, and expensive or high-risk medications. This protocol allowed us to consistently avoid using PCA. The PCA tethers patients to an IV pole if they would like to walk and still have pain relief. Multimodal analgesia without a PCA and urinary catheter allows patients to ambulate much more comfortably and effectively. Long-acting pain medications also improve sleep quality. We believe these are the reasons our patients were able to recover more quickly. It appears subjectively that our patients are more active and closer to their baseline activity level on postoperative day 3 with the ERAS protocol than they were on day 5 before we initiated ERAS.

There have been multiple updates to the literature since we created our ERAS protocol. In the future, we are considering stopping the oxycontin after the evening POD 0 dose, increasing the dexamethasone dose to 8 mg, and omitting the gabapentin[26] unless taken at home.

We acknowledge there are limitations with this study. Although the data from the ERAS group was collected prospectively, the historical data was collected retrospectively. As the prospective data was collected as part of a randomized controlled trial, there were exclusion criteria for the prospective portion of this study that were not present for the retrospective cohort. Fortunately, there were no significant differences regarding baseline characteristics as shown in Table 1.

There are many factors that can influence recovery that are not easily studied in a retrospective cohort design. An individual's frailty, anatomical variability, vascular status, and social factors including family support, and willingness to comply with treatment may have dramatic effects on one's speed of recovery. We have attempted to include all relevant medical history, but retrospective results do not account for improvements in care with time. We have attempted to address this with our non-significant segmental regression analysis and near perfectly matched groups. All cases were also performed by the same experienced surgeon, eliminating another source of variability. Our results are not generalizable to all settings.

Conclusions

In this cohort study, implementation of a robust enhanced recovery protocol with plain or liposomal bupivacaine was associated with significantly decreased opioid use despite unchanged pain scores, with improved markers of recovery including length of stay, time to oral only narcotics, and time to independent ambulation.

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Author Contributions

RG contributed to study conceptualization, study coordination, analyses, and manuscript preparation. GK contributed to manuscript and data preparation, collection of medical record data, and conceptualization of research project. AYH contributed to manuscript and data preparation, collection of inpatient data and surveys, and conceptualization of research project. RP contributed to manuscript and data preparation, collection of inpatient data and surveys, and conceptualization of research project. EO contributed to assistance with initial grant proposal and renewals, project conceptualization, power analysis, collection of inpatient data and surveys, and manuscript preparation. LZ contributed to data preparation, analysis, and manuscript preparation. TMM contributed to study conceptualization, grant funding, study coordination, analyses, manuscript preparation, surgeries, and postoperative outpatient data collection.

Implication Statement

In this cohort study, implementation of a robust enhanced recovery protocol with paravertebral analgesia in breast reconstruction surgery was associated with significantly decreased opioid use despite unchanged pain scores, with improved markers of recovery including length of stay, time to oral only narcotics, and time to independent ambulation. Liposomal bupivacaine vs plain bupivacaine use did not affect the results.

Submission Declaration

This work has not been published previously and is not under consideration for publication elsewhere. Its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. All co-authors have read and approved this manuscript.

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Supplemental Material

Supplemental material for this article is available online.

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