

Evaluating the Efficacy of Two Regional Pain Management Modalities in Autologous Breast Reconstruction

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Background: At our institution, multimodal opiate-sparing pain management is the cornerstone of our enhanced recovery program for autologous breast reconstruction. The purpose of this study was to compare postoperative outcomes and pain control metrics following implementation of an enhanced recovery program with two different regional analgesia approaches.

Methods: This retrospective cohort study identified 145 women who underwent autologous breast reconstruction from 2015 to 2017. Three groups were included: historical control patients (n = 46) and enhanced recovery patients that received multimodal pain management including a postoperative transversalis abdominis plane block with either a continuous local anesthetic catheter (n = 60) or a single-shot of liposomal bupivacaine (n = 39). The primary outcome was pain scores in the first three postoperative days. Secondary outcomes were opioid consumption in oral morphine equivalents and length of stay.

Results: Postoperative pain scores were similar across all three groups until postoperative day 3. Length of stay was significantly shorter in both of the enhanced recovery cohorts (3.0 [3.0, 4.0]) compared with control patients (4.0 [4.0, 5.0], $P < 0.001$). Likewise, average total oral morphine equivalents consumption was significantly reduced in enhanced recovery patients (continuous catheter 215.9 (95% CI, 165.4–266.3); liposomal bupivacaine 211.0 (95% CI, 154.8–267.2); control 518.4 (95% CI 454.2–582.7), $P < 0.001$). Neither length of stay ($P = 0.953$), nor oral morphine equivalents consumption ($P = 0.883$) differed by type of regional analgesia.

Conclusion: Compared with control patients, both approaches to regional transversalis abdominis plane block analgesia as part of an opiate-sparing enhanced recovery pain management strategy were successful, but neither superior to the other. (*Plast Reconstr Surg Glob Open* 2022;10:e4010; doi: [10.1097/GOX.0000000000004010](https://doi.org/10.1097/GOX.0000000000004010); Published online 19 January 2022.)

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INTRODUCTION

Autologous breast reconstruction is associated with increased patient satisfaction and quality of life when compared with no reconstruction or implant-based breast reconstruction.¹ Abdominally-based free tissue transfer is widely performed for unilateral or bilateral breast reconstructions in operations that may last from 4 to 12 hours, during which patients are predisposed to significant intraoperative fluid shifts/losses, hemodynamic changes, and intra/postoperative pain.

Introduced by Kehlet et al in 1997, fast-track recovery pathways and enhanced recovery protocols are well established in many surgical areas, including autologous breast reconstruction.^{2–8} Fundamentally, these protocols rely on adequate pain control to achieve reduced surgical stress, shortened length of stay (LOS), optimization of healthcare resource utilization, and improved patient

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satisfaction. Moreover, given the ongoing prescription opioid epidemic in the United States, these protocols largely emphasize the use of nonopioid analgesia, including local anesthetic.^{2,9} In microvascular breast reconstruction, the use of local anesthetic to reduce abdominal donor site pain varies from institutional mixtures of bupivacaine or liposomal bupivacaine placed in the subcutaneous and transversalis abdominis plane (TAP) to placement of continuous infusion catheters by the anesthesia or surgical teams.^{4,5,8,10–12} Depending on the modality used, there are implications to the extent and duration of pain control achieved, burden to the patient with additional catheter placement, as well as cost considerations.

The purpose of this study was to compare postoperative outcomes, namely pain control metrics following implementation of an enhanced recovery program with two different regional analgesia approaches. Specifically, after 6 months of protocol implementation, we changed the regional analgesia technique from bilateral indwelling continuous catheter TAP blocks with On-Q pumps to a one-time bilateral infiltration TAP block with liposomal bupivacaine to investigate whether the utilization of the less invasive TAP block technique influences pain control, LOS, and oral morphine equivalents (OME).

METHODS

Enhanced Surgical Recovery Protocol

A multidisciplinary team designed the Enhanced Surgical Recovery (ESR) protocol for our patients who underwent free flap-based breast reconstruction, encompassing the core components of the Enhanced Recovery After Surgery and Perioperative Surgical Home pathways.^{5,13–17} Briefly, we focused on opiate-sparing multimodal pain management as a critical element of the ESR protocol. In addition, we standardized preoperative patient work-up, intraoperative and postoperative fluid management, and postoperative nutrition and activity to accelerate recovery and shorten postoperative LOS.¹⁸ Standardized medications and dosing for each phase of care, as well as other elements of the enhanced recovery pathway are summarized in [Figure 1](#).

With the initiation of the ESR protocol, all patients undergoing microvascular breast reconstruction were identified preoperatively and received gabapentin, acetaminophen, oxycodone, and transdermal scopolamine to help prevent postoperative pain and nausea. In the operating room, opioid use was limited to the induction of anesthesia at the discretion of the managing anesthesiology team; patients were otherwise maintained without the use of long acting opioid narcotics. Ketamine was administered as the primary analgesic agent, up until 1 hour before emergence. Other intraoperative interventions included the use of an oral or nasally introduced esophageal Doppler to facilitate goal-directed fluid management and additional nausea/vomiting prophylaxis (dexamethasone and ondansetron).^{16,19}

As part of the protocol, regional anesthetic use was employed. During the first 6 months of our ESR

Takeaways

Question: Does a single shot of liposomal bupivacaine as part of a TAP block regional pain management strategy for autologous breast reconstruction provide any additional clinical benefit when compared with conventional bupivacaine infused via continuous local anesthetic catheter?

Findings: We show that both pain management strategies reduce hospital length of stay and postoperative opiate consumption, all while maintaining equivalent pain control when compared with a historical control group. Neither TAP block strategy provides any additional benefit when compared with the other.

Meaning: Compared with control patients, both TAP block approaches as part of an opiate-sparing pain management strategy were effective, but neither superior to the other.

program, TAP blocks were performed with the placement of elastomeric pumps (On-Q). Subsequently, for patients on the ESR protocol after the first 6 months, the elastomeric pump device was substituted with a one-time infiltration of liposomal bupivacaine in the TAP plane (duration of action 48–72 hours; Exparel; Pacira Pharmaceuticals, Inc).²⁰ In addition to TAP blockade, scheduled acetaminophen, ibuprofen, gabapentin, and PRN ketorolac/opiates provided comprehensive multimodal postoperative pain management, as previously described.³

In the immediate postoperative period, patients were transferred to the post-anesthesia care unit (PACU) where their standardized care continued ([Fig. 1](#)). After discharge from PACU, patients were transferred to a hospital floor with specialized nursing care for flap monitoring. Upon arrival to the floor, the scheduled regimen of nonopioid pain medications was started, leaving opiates as backup for breakthrough pain. Unrestricted diet was started on the day of surgery [postoperative day (POD) 0], maintenance intravascular fluids were discontinued, and urinary catheters were removed at the discretion of the surgical team, typically on POD1. Patients were encouraged to chair POD0 and began ambulation POD1. Pain scores were assessed through all phases of care by nursing staff using the standard Verbal Analog Scale (0–10, 0 being no pain and 10 being the worst pain imaginable).

Surgical Technique

The abdominal flap harvests [eg, free transverse rectus abdominis myocutaneous (TRAM), muscle-sparing TRAM, deep inferior epigastric perforator artery, or superficial inferior epigastric perforator artery] and choice of recipient vessels for the flaps utilized in this study have been previously described.^{5,21} Briefly, the decision to harvest a full muscle TRAM, muscle-sparing TRAM, or deep inferior epigastric perforator artery/superficial inferior epigastric perforator artery flap was largely made intraoperatively based on quality and size of perforating vessels, intra-muscular course of the vascular pedicle, preoperative imaging, and surgeon preference. The internal mammary

PREOPERATIVE

- Oxycodone 10 mg PO
- Gabapentin 900 mg PO
- Acetaminophen 975 mg PO
- Scopolamine TD

INTRAOPERATIVE

- Dexamethasone 4 mg IV
- Ondansetron 4 mg IV
- Ketamine 0.25 mg/kg/hour
- Fentanyl < 2–4 mcg/kg
- AVOID Hydromorphone
- Esophageal Doppler to assist fluid management
- Normotension, normothermia, and normoglycemia

PACU

- On-Q pump / Liposomal Bupivacaine to abdominal incision
- Promethazine 6.25 mg IV PRN
- Haloperidol 1 mg IV PRN
- Ketorolac 30 mg IV PRN
- Oxycodone 5–10 mg PO PRN
- Hydromorphone 0.2–0.5 mg IV PRN

HOSPITAL FLOOR

- Acetaminophen 650 mg PO TID × 6
- Ibuprofen 800 mg PO TID × 6
- Gabapentin 100 mg TID
- Oxycodone 5–10 mg PO q4h PRN
- Hydromorphone 0.2–0.5 mg IV q4h PRN
- Early out-of-bed to chair and ambulation
- Antibiotic prophylaxis and thromboprophylaxis per standard of care
- Early discontinuation of catheters and IV lines

Fig. 1. Pharmacology and core elements of ESR protocol.

vessels were used as recipient vessels, and the decision to expose the internal mammary vessels via a rib sparing technique or by removing a portion of rib cartilage was left to surgeon preference. In the majority of study patients, TAP blocks were performed by incising the external oblique fascia for a length of 2–3 cm just cephalad and slightly medial to the anterior superior iliac spines and splitting the exposed external oblique muscles along their fibers, followed by splitting the internal oblique muscles to expose the transversus abdominus plane where placement of On-Q continuous infusion catheters or injection of liposomal bupivacaine was completed by the surgical team under direct visualization. Subsequently, the external oblique fascia was repaired using resorbable polyglactin suture. The On-Q pump contained 400 cm³ of 0.5% bupivacaine with an infusion of rate of 4 cm³ per hour and typically remained in place until the elastomeric pumps were empty. In patients that received liposomal bupivacaine, 60 cm³ of a mixture containing 266 mg of liposomal bupivacaine diluted in 120 cm³ of saline were injected as two equal doses with a 21 gauge spinal needle into each TAP plane under direct visualization.

Study Design

This retrospective cohort study at The Ohio State University Wexner Medical Center included 145 women who underwent autologous breast reconstruction from 2015 to 2017. Institutional review board approval was obtained (IRB ID: 2017C0017). Three groups of patients

were included: historical control patients (n = 46) and enhanced recovery patients that received multimodal pain management, including a postoperative TAP block with either a continuous local anesthetic catheter (ESR CATH, n = 60) or a single-shot of liposomal bupivacaine (ESR INJECT, n = 39).

Outcomes Description

The primary outcome of this study was postoperative pain scores throughout POD3. Pain scores used for our analysis included highest pain score during PACU stay and average pain scores on POD1, 2, and 3. Secondary outcomes were perioperative opiate consumption and LOS, defined as the number of days from hospital admission until postoperative discharge. Opiate consumption was determined by converting all forms of opiate intake to OME.²²

STATISTICAL ANALYSIS

Subject demographics and clinical characteristics were summarized using descriptive statistics (ie, means, SDs for continuous variables, and frequencies for categorical data), and compared across all three groups. LOS was summarized by study group as median and interquartile-range [IQR] and univariate hypothesis testing was conducted using a Kruskal-Wallis chi-squared test. After noting no significant difference in demographics among the three groups, a multivariate logistic regression model was fit assessing the difference in a binary discharge days

variable (Discharged \geq POD5 or $<$ POD5) between study groups adjusting for surgery timing (immediate versus delayed reconstruction), surgery length, surgery laterality (unilateral versus bilateral reconstruction), and complications requiring return reoperation before discharge (ie, bleeding, flap compromise, and mastectomy skin flap necrosis). A multivariable adjusted longitudinal mixed model was also fit for opiate use metrics across hospitalization phase, to compare study groups while adjusting for the same covariates listed above. An additional multivariable adjusted general linear model was fit to compare total OME consumption between study groups while adjusting for the same covariates listed above. Relevant model-based estimates and 95% confidence intervals are reported. Missing data were considered to be missing at random. All hypothesis testing was conducted at an alpha level of 0.05. SAS (version 9.4; SAS Institute, Cary, N.C.) was used for all statistical analyses.

RESULTS

Patient Population and Intraoperative Variables

Data from 145 patients were analyzed. Baseline patient characteristics were similar among the three groups. Patients in the ESR CATH group were younger when compared with control and ESR INJECT (years, control 54.0 ± 10.4 ; ESR CATH 50.3 ± 10.4 ; ESR INJECT 54.9 ± 8.9 , $P = 0.050$) (Table 1). Need for multiple surgeries, surgery timing (immediate versus delayed reconstruction), and surgery length were not different between the three groups (Table 2). Patients in the ESR INJECT group had a higher percentage of bilateral reconstructions (51%) when compared with control and ESR CATH groups (26% and 37%, respectively; $P = 0.057$), but bilateral procedures were completed quicker in the ESR INJECT group (hours, control 13.8 ± 1.4 ; ESR CATH 12.7 ± 1.6 ; ESR INJECT 11.9 ± 1.6 , $P = 0.005$). Despite incorporation of esophageal Doppler in the ESR protocol for goal-directed fluid management, total liters (L) of intraoperative fluid administration did not differ between the three groups (Control 5.2 ± 1.9 L; ESR CATH 5.0 ± 1.6 L; ESR INJECT 5.0 ± 1.0 L; $P = 0.77$), and use of colloids was similar between groups (Table 2).

Multimodal Pain Management

Overall compliance with the ESR opiate-sparing pain management plan was excellent (91% in both ESR

groups, Table 3). Ketamine was administered intraoperatively to 97% of patients in the ESR CATH group and to all patient in the ESR INJECT group, the majority of patients received between 100 and 200 mg (Table 2). The majority of patients received a TAP block as per their study group (control 73.9% received On-Q; ESR CATH 81.7% received On-Q; ESR INJECT 100% received liposomal bupivacaine, $P < 0.001$) (Table 2). All patients in the control group received a PCA pump with opioid medication for postoperative pain control. One patient in each ESR group required a PCA for postoperative pain control.

Primary Outcome

Pain Scores

A longitudinal mixed model analysis was fit to estimate mean pain scores adjusting for study group and postoperative time (Fig. 2). Pain scores were similar when comparing the three groups at different postoperative time points. There was no significant difference in pain scores between the ESR INJECT group and the control group at any time point after surgery, and pain scores only differed significantly between the ESR CATH (estimated mean, 3.1; 95% CI, 4.1–5.3) and control group (estimated mean, 1.8; 95% CI, 1.1–2.5) on POD3 ($P = 0.0082$).

Secondary Outcomes

Oral Morphine Equivalents

Average total OME for the ESR CATH group was 215.9 (95% CI, 165.4–266.3) and 211.0 (95% CI, 154.8–267.2) for the ESR INJECT group, compared with 518.4 (95% CI, 454.2–582.7) for the control group ($P < 0.001$), after adjusting for surgical timing, surgical length, surgical laterality, and multiple surgeries. Average total OME was similar between ESR groups ($P = 0.883$). We further analyzed OME longitudinally by hospitalization phase while adjusting for surgery timing, surgery length, surgery laterality, and multiple surgeries using a multivariable linear mixed model, which indicated that ESR patients received significantly less OME when compared with the historical controls (Table 4). With the exception of PACU, significantly less OME use was seen in the ESR groups compared with control when stratifying by phases of perioperative care (Preoperative and intraoperative $P = 0.001$; Postoperative $P < 0.001$). During the PACU period, OME use was similar across all groups ($P = 0.775$). Average total OME and OME use across perioperative phases was not different between the ESR CATH and ESR INJECT groups.

Table 1. Patient Baseline Characteristics

Characteristic	Control (n = 46)	ESR CATH (n = 60)	ESR INJECT (n = 39)	P
Age, mean \pm SD	54.0 \pm 10.4	50.3 \pm 10.4	54.9 \pm 8.9	0.050
BMI, mean \pm SD, kg/m ²	31.4 \pm 6.8	30.1 \pm 5.7	31.3 \pm 5.0	0.473
Hypertension, n (%)	13 (28)	15 (25)	15 (39)	0.347
Diabetes mellitus, n (%)	2 (5)	4 (7)	4 (10)	0.561
Smoking history, n (%)				
Never	32 (70)	42 (70)	26 (67)	0.584
Former	13 (28)	15 (25)	13 (33)	
Current	1 (2)	3 (5)	0 (0)	

Table 2. Intraoperative Variables

Variable	Control (n = 46)	ESR CATH (n = 60)	ESR INJECT (n = 39)	P
Laterality, n (%)				
Unilateral	34 (74)	38 (63)	19 (49)	0.057
Bilateral	12 (26)	22 (37)	20 (51)	
Surgery timing, n (%)				
Immediate	35 (76)	42 (70)	25 (64)	0.482
Delayed	11 (24)	18 (30)	14 (36)	
Surgery length – laterality, mean ± SD, h				
Unilateral	9.5 ± 1.3	9.8 ± 1.5	10.0 ± 1.4	0.471
Bilateral	13.8 ± 1.4	12.7 ± 1.6	11.9 ± 1.6	0.005
Surgery length – timing, mean ± SD, h				
Immediate	10.3 ± 2.2	10.9 ± 1.9	10.8 ± 1.7	0.398
Delayed	11.7 ± 2.4	10.8 ± 2.4	11.2 ± 1.9	0.604
Multiple surgeries, n (%)	6 (17)	10 (17)	8 (21)	0.886
Esophageal Doppler, n (%)	0 (0)	54 (90)	28 (72)	<0.001
Fluid administration, mean ± SD, l				
Total fluid	5.2 ± 1.9	5.0 ± 1.6	5.0 ± 1.0	0.766
Total colloid	0.3 ± 0.7	0.3 ± 0.5	0.5 ± 0.5	0.326
Regional anesthesia, n (%)				
None	12 (26)	11 (18)	0 (0)	<0.001
On-Q pump	34 (74)	49 (82)	0 (0)	
Liposomal bupivacaine	0 (0)	0 (0)	39 (100)	
Total ketamine administration, n (%)				
0 mg	36 (78)	2 (3)	0 (0)	<0.001
>0 to <100 mg	6 (13)	12 (20)	6 (15)	
100 to <200 mg	3 (7)	29 (48)	22 (56)	
>200 mg	1 (2)	17 (28)	11 (28)	

Length of Stay

Median LOS for the historical control group was 4.0 days [4.0, 5.0]. LOS was significantly shorter in both of the ESR cohorts (days, ESR CATH 3.0 [3.0, 4.0]; ESR INJECT 3.0 [3.0, 4.0]) *P* < 0.001 (Fig. 3). LOS was similar in the ESR CATH and ESR INJECT (*P* = 0.953). A multivariate logistic regression model was fit to estimate the predictive probability of discharge on POD5 or later versus earlier than POD5 adjusting for multiple surgeries, surgical timing, surgery length, and surgical laterality. Patients in the historical control group had a significantly higher predictive probability of prolonged LOS to POD5 or later rather than POD4 or earlier when compared with the ESR CATH group (0.62 [95% CI, 0.36–0.83] versus 0.08 [95% CI,

0.03–0.24]; OR 17.51 [95% CI, 3.60–85.23], *P* < 0.001) and the ESR INJECT group (0.18 [95% CI, 0.03–0.24]; OR 7.54 [95% CI, 1.77–32.06], *P* = 0.006) (Table 5). The predictive probability of discharge on POD5 or later between the ESR INJECT group and ESR CATH group did not significantly differ (OR 2.32 [95% CI, 0.49–11.01], *P* = 0.299).

DISCUSSION

In autologous breast reconstruction, enhanced recovery protocols are now widely utilized.²³ Through excellent overall compliance with a custom ESR protocol, we demonstrate decreased LOS and OME use in our microvascular breast reconstruction patients

Table 3. Compliance with ESR Multimodal Pain Management

No. (%)	Patient Group	
	ESR CATH (n = 60)	ESR INJECT (n = 39)
Core Element of ESR		
Preoperative		
Acetaminophen	60 (100)	38 (97)
Gabapentin	56 (93)	37 (95)
Oxycodone	54 (90)	36 (92)
Preoperative average	94%	95%
Intraoperative		
TAP block	49 (82)	39 (100)
Ketamine	58 (97)	39 (100)
Intraoperative average	89%	100%
Postoperative		
Hydromorphone PCA*	1 (98)	1 (97)
Gabapentin	51 (85)	36 (92)
Acetaminophen		
Started by POD0	53 (88)	37 (95)
6/6 doses	55 (92)	28 (72)
Ibuprofen		
Started by POD0	51 (85)	37 (95)
6/6 doses	50 (83)	28 (72)
Postoperative average	89%	87%
Overall average compliance	91%	91%

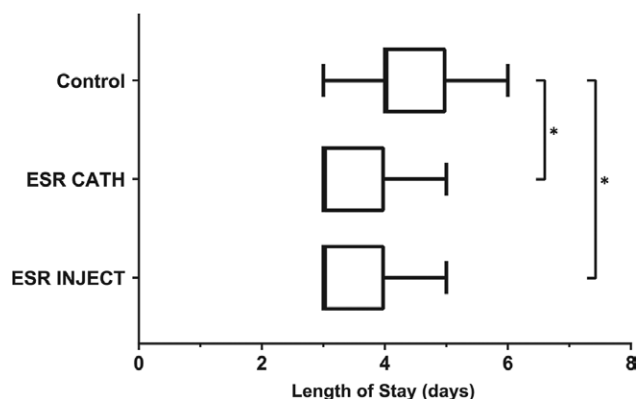


Fig. 2. Longitudinal Mixed Model Pain Score estimated means (95% CI) by study group and time during hospitalization. Longitudinal mean score number (95% CI). Highest pain score was reported in PACU and average 24-hour pain scores were reported from POD1 to POD3. Number of patients control group POD 1 = 45, ESR CATH number of subjects POD2 = 58, ESR CATH number of subjects POD 3 = 57. *Statistical significance (*P* = 0.008).

Table 4. Multivariate Adjusted Model Estimated OME Consumption

Adjusted Mean (95% CI), mg	Patient Group						P
	Control (n = 46)	ESR CATH (n = 60)	ESR INJECT (n = 39)	Overall	Control-ESR CATH	Control-ESR INJECT	
Perioperative phase*							
Preoperative and intraoperative	116.5 (99.1–133.9)	83.0 (69.3–96.6)	86.3 (71.1–101.5)	0.001	<0.001	0.004	0.710
PACU	10.9 (6.6–15.2)	11.3 (7.9–14.7)	9.7 (5.9–13.5)	0.775	0.875	0.640	0.480
Postoperative	391.1 (331.4–450.8)	121.6 (74.8–168.5)	115.0 (62.8–167.2)	<0.001	<0.001	<0.001	0.830
Multivariate Adjusted Linear Model for Total Oral Morphine Equivalents							
	Control (n = 46)	ESR CATH (n = 60)	ESR INJECT (n = 39)	Overall	Control-ESR CATH	Control-ESR INJECT	ESR CATH- ESR INJECT
Perioperative Phase#	518.4 (454.2–582.7)	215.9 (165.4–266.3)	211.0 (154.8–267.2)	<0.001	<0.001	<0.001	0.883
Total hospitalization							

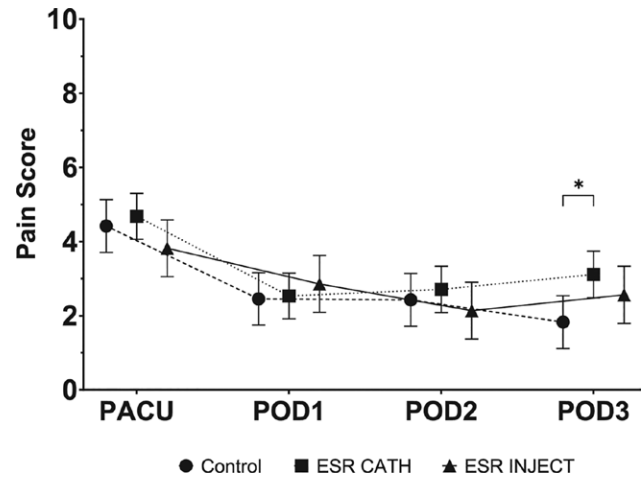


Fig. 3. Hospital LOS. *Statistical significance ($P < 0.001$).

compared with preprotocol patients, while maintaining clinically equivalent pain control. This is consistent with several previous reports of improved outcomes with implementation of enhanced recovery protocols and use of regional anesthesia.^{4,5,10,11,24,25} Unique from previous reports, our protocol emphasizes minimization of opiates in all phases of care, including the use of ketamine intraoperatively. Moreover, we demonstrate equivalent pain control with two regional analgesic modalities.

Batdorf et al instituted the first comprehensive multimodal enhanced recovery pathway for microvascular breast reconstruction patients in their report of 100 (49 enhanced recovery cohort, 51 historical control) free TRAM and deep inferior epigastric perforator artery breast reconstruction patients. Similar to our protocol, they included interventions in all phases of perioperative care, including the use of liposomal bupivacaine for TAP block. The authors noted a significant decrease in duration of hospital stay and inpatient opiate use, although 20% of their enhanced recovery patients required a PCA after surgery.⁵ While both the Batdorf protocol and our protocol called for administration of preemptive multimodal PO analgesia before surgery, intraoperative narcotic use was left to the discretion of anesthesiology by Batdorf et al. Conversely, our protocol emphasized minimization of intraoperative opiates and the use of ketamine analgesia. Interestingly, administering preoperative oxycodone, acetaminophen, and gabapentin may help decrease pain to a level that allows for ketamine to be effective in lieu of opioid narcotics intraoperatively. Additionally, preoperative gabapentin may help achieve steady state levels sooner, to ultimately decrease the need for opioid medication postoperatively. In addition to postoperative acetaminophen and NSAID use, we added gabapentin for multimodal pain control. Only two of 99 patients required a PCA after ESR implementation in our study. Of note, PCAs were started in PACU but their OME contribution was first computed 8 hours after initiation (ie, when patients were on the postoperative floor); therefore, PACU OME

Table 5. Multivariate Logistic Regression Model Results for LOS (<5 versus ≥5 days)

Risk Factor	Odds Ratio	95% CI	Pairwise P	Overall P
Control versus ESR CATH	17.51	3.60–85.23	<0.001	
Control versus ESR INJECT	7.54	1.77–32.06	0.006	
ESR INJECT versus ESR CATH	2.32	0.49–11.01	0.299	<0.001
Unilateral versus bilateral reconstruction	0.55	0.10–2.93		0.482
Immediate versus delayed reconstruction	0.66	0.18–2.44		0.528
Surgery length	1.24	0.84–1.81		0.278
Multiple surgeries	0.08	0.02–0.31		<0.001

actually represents nursing opiate administration only. It is possible that PACU OME may indicate less opiate requirements in the ESR patients during their PACU stay, as they did not have a supplemental PCA at bedside like control patients.

Although our data indicate that equivalent pain control was achieved in the control and ESR groups despite a great reduction in OME, this is confounded by the increased levels of activity encouraged after the implementation of the ESR protocol. Historically, patients remained on bedrest POD0, progressing to a bedside chair on POD1, whereas after ESR, patients were allowed to the chair on POD0 and regular ambulation on POD1. Furthermore, ESR patients achieve discharge milestones sooner, including basic activities of daily living. Therefore, although the effects of each component of ESR (eg, activity, medication regimens) are difficult to discern and there is certainly a limitation of all studies examining the effects of ESR on LOS and OME, similar pain scores in the control and ESR groups despite increased activity in the ESR groups may actually indicate improved pain control in ESR patients.

Recent studies denote conflicting results on the superiority of liposomal bupivacaine over conventional bupivacaine for use in abdominally-based autologous breast reconstruction.^{4,5,26–29} At our institution, the transition to a less invasive TAP block technique with infiltration of liposomal bupivacaine did not result in additional reductions in pain scores or in LOS or OME. Cost associated with the different regional modalities remains an important implication that is beyond the scope of this study.

In addition to the limitations aforementioned, this study also has the limitations associated with all retrospective analyses. Lastly, we present a limited sample size from a single institution, including several surgeons.

CONCLUSIONS

We designed a comprehensive ESR program for women who underwent autologous free flap microvascular breast reconstruction, with a focus on multimodal opiate-sparing pain management throughout all phases of care. Overall, we had excellent protocol compliance by the care team and demonstrated similar pain scores despite reductions in median LOS (1 full day, 25%) and opiate consumption (>60%). These differences remained consistent with two regional analgesia approaches, a continuous indwelling catheter TAP block, and a single-administration TAP block with liposomal bupivacaine.

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REFERENCES

- Cederna PS, Yates WR, Chang P, et al. Postmastectomy reconstruction: comparative analysis of the psychosocial, functional, and cosmetic effects of transverse rectus abdominis musculocutaneous flap versus breast implant reconstruction. *Ann Plast Surg.* 1995;35:458–468.
- Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. *Br J Anaesth.* 1997;78:606–617.
- Rendon JL, Hodson T, Skoracki RJ, et al. Enhanced recovery after surgery protocols decrease outpatient opioid use in patients undergoing abdominally based microsurgical breast reconstruction. *Plast Reconstr Surg.* 2020;145:645–651.
- Afonso A, Oskar S, Tan KS, et al. Is enhanced recovery the new standard of care in microsurgical breast reconstruction? *Plast Reconstr Surg.* 2017;139:1053–1061.
- Batdorf NJ, Lemaine V, Lovely JK, et al. Enhanced recovery after surgery in microvascular breast reconstruction. *J Plast Reconstr Aesthet Surg.* 2015;68:395–402.
- Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery: a review. *JAMA Surg.* 2017;152:292–298.
- Sebai ME, Siotos C, Payne R, et al. Enhanced recovery after surgery pathway for microsurgical breast reconstruction: a systematic review and meta-analysis. *Plast Reconstr Surg.* 2019;143:655–666.
- Afonso AM, Newman MI, Seeley N, et al. Multimodal analgesia in breast surgical procedures: technical and pharmacological considerations for liposomal bupivacaine use. *Plast Reconstr Surg Glob Open.* 2017;5:e1480.
- Kehlet H. Multimodal approach to postoperative recovery. *Curr Opin Crit Care.* 2009;15:355–358.
- Bonde CT, Khorasani H, Elberg J, et al. Perioperative optimization of autologous breast reconstruction. *Plast Reconstr Surg.* 2016;137:411–414.
- Kaoutzanis C, Ganesh Kumar N, O'Neill D, et al. Enhanced recovery pathway in microvascular autologous tissue-based breast reconstruction: should it become the standard of care? *Plast Reconstr Surg.* 2018;141:841–851.
- Vyas KS, Rajendran S, Morrison SD, et al. Systematic review of liposomal bupivacaine (exparel) for postoperative analgesia. *Plast Reconstr Surg.* 2016;138:748e–756e.
- Carroll I, Hah J, Mackey S, et al. Perioperative interventions to reduce chronic postsurgical pain. *J Reconstr Microsurg.* 2013;29:213–222.
- Gärtner R, Kroman N, Callesen T, et al. Multimodal prevention of pain, nausea and vomiting after breast cancer surgery. *Minerva Anestesiol.* 2010;76:805–813.
- Sharma S, Chang DW, Koutz C, et al. Incidence of hematoma associated with ketorolac after TRAM flap breast reconstruction. *Plast Reconstr Surg.* 2001;107:352–355.

16. Cannesson M, Gan TJ. PRO: perioperative goal-directed fluid therapy is an essential element of an enhanced recovery protocol. *Anesth Analg*. 2016;122:1258–1260.
17. Zhong T, Neinstein R, Massey C, et al. Intravenous fluid infusion rate in microsurgical breast reconstruction: important lessons learned from 354 free flaps. *Plast Reconstr Surg*. 2011;128:1153–1160.
18. Eskicioglu C, Forbes SS, Aarts MA, et al. Enhanced recovery after surgery (ERAS) programs for patients having colorectal surgery: a meta-analysis of randomized trials. *J Gastrointest Surg*. 2009;13:2321–2329.
19. Phan TD, Ismail H, Heriot AG, et al. Improving perioperative outcomes: fluid optimization with the esophageal Doppler monitor, a metaanalysis and review. *J Am Coll Surg*. 2008;207:935–941.
20. Food U, Administration D. FDA Label Approved on 10/28/2011 (PDF) for EXPAREL. US Silver Spring, MD: US Food and Drug Administration. Available at https://www.accessdata.fda.gov/drugsatfda_docs/label/2018/022496s030lbl.pdf. Accessed
21. Macadam SA, Bovill ES, Buchel EW, et al. Evidence-based medicine: autologous breast reconstruction. *Plast Reconstr Surg*. 2017;139:204e–229e.
22. Pereira J, Lawlor P, Vigano A, et al. Equianalgesic dose ratios for opioids: a critical review and proposals for long-term dosing. *J Pain Symptom Manage*. 2001;22:672–687.
23. Temple-Oberle C, Shea-Budgell MA, Tan M, et al; ERAS Society. Consensus review of optimal perioperative care in breast reconstruction: Enhanced Recovery after Surgery (ERAS) Society Recommendations. *Plast Reconstr Surg*. 2017;139:1056e–1071e.
24. Davidge KM, Brown M, Morgan P, et al. Processes of care in autogenous breast reconstruction with pedicled TRAM flaps: expediting postoperative discharge in an ambulatory setting. *Plast Reconstr Surg*. 2013;132:339e–344e.
25. Giordano S, Uusalo P, Oranges CM, et al. Local anesthetic pain catheters to reduce opioid use in massive weight loss patients undergoing abdominoplasty: a comparative study. *J Plast Reconstr Aesthet Surg*. 2020;73:770–776.
26. Gatherwright J, Knackstedt RW, Ghaznavi AM, et al. Prospective, randomized, controlled comparison of bupivacaine versus liposomal bupivacaine for pain management after unilateral delayed deep inferior epigastric perforator free flap reconstruction. *Plast Reconstr Surg*. 2018;141:1327–1330.
27. Ha AY, Keane G, Parikh R, et al. 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-blind, randomized, controlled trial. *Plast Reconstr Surg*. 2019;144:35–44.
28. Oh C, Moriarty J, Borah BJ, et al. Cost analysis of enhanced recovery after surgery in microvascular breast reconstruction. *J Plast Reconstr Aesthet Surg*. 2018;71:819–826.
29. Jablonka EM, Lamelas AM, Kim JN, et al. Transversus abdominis plane blocks with single-dose liposomal bupivacaine in conjunction with a nonnarcotic pain regimen help reduce length of stay following abdominally based microsurgical breast reconstruction. *Plast Reconstr Surg*. 2017;140:240–251.