

Retrospective analysis of quality improvement when using liposome bupivacaine for postoperative pain control

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Background/objective: Liposome bupivacaine, a prolonged-release bupivacaine formulation, recently became available at the Naval Medical Center San Diego (NMCSD); before availability, postsurgical pain for large thoracic/abdominal procedures was primarily managed with opioids with/without continuous thoracic epidural (CTE) anesthesia. This retrospective chart review was part of a clinical quality initiative to determine whether postsurgical outcomes improved after liposome bupivacaine became available.

Methods: Data from patients who underwent laparotomy, sternotomy, or thoracotomy at NMCSD from May 2013 to May 2014 (after liposome bupivacaine treatment became available) were compared with data from patients who underwent these same procedures from December 2011 to May 2012 (before liposome bupivacaine treatment became available). Collected data included demographics, postoperative pain control methods, opioid consumption, perioperative pain scores, and lengths of intensive care unit and overall hospital stays.

Results: Data from 182 patients were collected: 88 pre-liposome bupivacaine (laparotomy, n=52; sternotomy, n=26; and thoracotomy, n=10) and 94 post-liposome bupivacaine (laparotomy, n=49; sternotomy, n=31; and thoracotomy, n=14) records. Mean hospital stay was 7.0 vs 5.8 days ($P=0.009$) in the pre- and post-liposome bupivacaine groups, respectively, and mean highest reported postoperative pain score was 7.1 vs 6.2 ($P=0.007$), respectively. No other significant between-group differences were observed for the overall population. In the laparotomy subgroup, there was a reduction in the proportion of patients who received CTE anesthesia post-liposome bupivacaine (22% [11/49] vs 35% [18/52] pre-liposome bupivacaine).

Conclusion: Surgeons and anesthesiologists have changed the way they manage postoperative pain since the time point that liposome bupivacaine was introduced at NMCSD. Our findings suggest that utilization of liposome bupivacaine may be a useful alternative to epidural anesthesia.

Keywords: laparotomy, thoracotomy, sternotomy, anesthesia, local

Introduction

Postsurgical pain is a significant concern for patients undergoing inpatient and outpatient procedures at US hospitals. In a recent survey regarding pre- and postsurgical pain experiences of patients (N=300) from randomly selected surgical practices across the US, pain after surgery was the most prominent presurgery concern expressed by patients in the sample; 80% reported having concerns about postsurgical pain, and 46% indicated that these concerns resulted in “high” or “very high” levels of anxiety.¹ Such concerns are well founded, because approximately two-thirds of respondents reported experiencing postsurgical pain of moderate-to-extreme intensity.¹

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The inadequacy of postsurgical pain control has been recognized for decades,¹ and numerous government agencies and clinical societies have published recommendations with strategies intended to improve postsurgical analgesia practices.²⁻⁵ The American Pain Society, in collaboration with the Pain Care Coalition,⁶ has also advocated for the creation of a national pain and palliative care research and quality program that would ensure that military personnel, veterans, and Medicare beneficiaries receive appropriate pain management.⁷ However, despite these efforts, there appears to have been little or no improvement in patients' reported levels of postsurgical pain control over the past 20 years.¹

Opioid analgesics are a cornerstone of postsurgical pain management^{7,8} because these agents are widely recognized as the most effective option for controlling moderate-to-severe pain.^{7,8} However, commonly reported opioid-related adverse events (ORAEs), including constipation, nausea, and vomiting, can be burdensome,⁷⁻¹⁰ especially in the setting of abdominal surgery.^{11,12} In addition, health care costs have been reported to be higher for patients who experience ORAEs because of increased pharmacy and nursing requirements and increased length of hospital stay.⁷⁻⁹ To minimize the risk of ORAEs while still providing adequate postsurgical pain control, the American Society of Anesthesiologists (ASA) recommends the use of multimodal approaches to pain management that incorporate perioperative infiltration of local anesthetics into surgical incision sites whenever possible.³

Historically, postsurgical analgesia regimens used at the Naval Medical Center San Diego (NMCS D) for patients undergoing chest or abdominal surgery consisted of opioid analgesia with adjunctive use of a continuous thoracic epidural (CTE) anesthesia in some of the laparotomy cases. In May 2013, liposome bupivacaine became available, on a restricted basis, for use at NMCS D. This prolonged-release liposomal formulation of bupivacaine is indicated for single-dose administration into the surgical site to produce postsurgical analgesia.¹³ The safety and efficacy of liposome bupivacaine-based multimodal analgesic regimens compared with bupivacaine HCl and intravenous opioid-based patient-controlled analgesia have been investigated in several surgical models across multiple Phase II, III, and IV studies.¹⁴⁻¹⁶ Positive outcomes have also been reported in exploratory prospective and retrospective studies that evaluated transversus abdominis plane (TAP) infiltration of liposome bupivacaine for postsurgical analgesia in patients undergoing abdominoplasty, hysterectomy, prostatectomy, or umbilical hernia repair.¹⁷⁻²⁰ On the basis of these findings, we

hypothesized that incorporating liposome bupivacaine into multimodal analgesia regimens at NMCS D could result in clinical quality improvement (CQI).

This analysis evaluated whether postsurgical outcomes, including pain scores, opioid consumption, length of intensive care unit (ICU) stay, and length of hospital stay, improved after liposome bupivacaine became available at NMCS D for use in patients undergoing laparotomy, sternotomy, or thoracotomy procedures. The objective was to determine whether possible quality improvements associated with liposome bupivacaine justify the additional pharmacy cost of liposome bupivacaine compared with traditional postsurgical analgesia.

Methods

Study design

This analysis was based on a retrospective chart review performed for CQI purposes. As such, CQI was implemented as part of practices administered to improve patient care at NMCS D; the analysis was not required to go through a formal institutional review board process or obtain informed consent, as per guidance from the US Department of Health and Human Services.²¹ Data from all patients who underwent laparotomy, sternotomy, or thoracotomy procedures during the 12 months after liposome bupivacaine (bupivacaine liposome injectable suspension, EXPAREL[®]; Pacira Pharmaceuticals, Inc, Parsippany, NJ, USA)¹³ became available at NMCS D (May 2013 through May 2014; post-liposome bupivacaine group) were compared with data from patients who underwent these same surgical procedures during the 6 months before the introduction of liposome bupivacaine at NMCS D (December 2011 through May 2012; pre-liposome bupivacaine group). Patients were identified for inclusion using current procedural terminology (CPT[®]) codes for laparotomy, sternotomy, and thoracotomy (Table 1). Pain control methods used in these surgical procedures included CTE anesthesia (laparotomy patients only), TAP block, wound infiltration with liposome bupivacaine, and wound infiltration via elastomeric pump (used prior to formulary adoption of liposome bupivacaine for thoracotomy procedures; patients received a continuous infusion of bupivacaine HCl into their surgical wound for 3 days after surgery).

Outcomes

Each medical record was reviewed and relevant data were extracted for each patient. Collected demographic and baseline clinical characteristics included age, sex, ASA physical status classification score, and preoperative pain score on an

Table 1 Current procedural terminology (CPT®) codes used to identify patients who underwent laparotomy, sternotomy, or thoracotomy at Naval Medical Center San Diego

Code	Description
Laparotomy	
38747	Radical lymphadenectomy (radical resection of lymph nodes)
43300	Repair procedures on the esophagus
43611	Excision procedures on the stomach
44140	Excision procedures on the intestines (except rectum)
44143	Excision procedures on the intestines (except rectum)
44146	Excision procedures on the intestines (except rectum)
44156	Excision procedures on the intestines (except rectum)
44204	Laparoscopic excision procedures on the intestines (except rectum)
44212	Laparoscopic excision procedures on the intestines (except rectum)
44625	Repair procedures on the intestines (except rectum)
45110	Excision procedures on the rectum
45550	Repair procedures on the rectum
47563	Laparoscopic procedures on the biliary tract
48140	Excision procedures on the pancreas
48153	Excision procedures on the pancreas
49000	Incision procedures on the abdomen, peritoneum, and omentum
51860	Repair of bladder wound
53240	Excision procedures on the urethra
58200	Hysterectomy procedures
58247	Removal of pelvis contents
58953	Excision procedures on the ovary
58954	Excision procedures on the ovary
58956	Excision procedures on the ovary
Sternotomy	
21825	Fracture and/or dislocation procedures on the neck (soft tissues) and thorax
33300	Surgical procedures on the heart (including valves) and great vessels
33335	Insertion of major vessel graft
33365	Aortic valve replacement
33405	Surgical procedures on the aortic valve
33425	Surgical procedures on the mitral valve
33426	Surgical procedures on the mitral valve
33430	Surgical procedures on the mitral valve
33465	Surgical procedures on the tricuspid valve
33510	Coronary artery bypass graft
33533	Arterial grafting for coronary artery bypass
33730	Repair procedures for venous anomalies
33863	Repair procedures for thoracic aortic aneurysm
33864	Repair procedures for thoracic aortic aneurysm
39220	Excision/resection procedures on the mediasternum
Thoracotomy	
21620	Excision procedures on the neck (soft tissues) and thorax
32096	Incision procedures on the lungs and pleura (open wedge)
32097	Incision procedures on the lungs and pleura (open wedge and biopsy)
32100	Incision procedures on the lungs and pleura (chest exploration)
32110	Incision procedures on the lungs and pleura (chest exploration and repair)
32141	Incision procedures on the lungs and pleura (remove bullae)

(Continued)

Table 1 (Continued)

Code	Description
32480	Removal procedures on the lungs and pleura
32608	Thoracoscopy (VATS) on the lungs and pleura
32654	Thoracoscopy (VATS) on the lungs and pleura
32666	Thoracoscopy (VATS) on the lungs and pleura

Notes: CPT copyright 2014, American Medical Association. All rights reserved.⁴¹
Abbreviation: VATS, video-assisted thoracic surgery.

eleven-point numeric rating scale (NRS; 0= no pain to 10= worst pain imaginable). Pain scores captured in nursing notes were also recorded at 4-hour intervals during the first 72 hours after surgery. Postsurgical consumption of intravenous and oral opioids (converted to oral morphine equivalents) was recorded for each patient; drugs used included morphine, hydromorphone, fentanyl, meperidine, hydrocodone, and oxycodone. Length of ICU stay and total hospital length of stay (both in days) were recorded for each patient.

Data analysis

Data for patients in the pre- and post-liposome bupivacaine groups were stratified by surgery type (laparotomy, sternotomy, or thoracotomy). Additional subset analyses were performed for the laparotomy group based on pain control method (CTE anesthesia or no CTE in the pre-liposome bupivacaine group, and CTE anesthesia only or liposome bupivacaine only in the post-liposome bupivacaine group). Epidural use was not an option for sternotomy or thoracotomy procedures.

Comparisons between the pre- and post-liposome bupivacaine groups were made for the outcomes of overall mean and highest mean pain scores through 72 hours postsurgery, opioid use (milligrams of oral morphine equivalents), length of ICU stay, and length of hospital stay. Data were summarized using descriptive statistics. The between-group comparisons were conducted using a *t*-test, with the significance level set at $P < 0.05$.

Results

Patients

A total of 182 patients were included in the analysis: 88 in the pre-liposome bupivacaine group (laparotomy, $n=52$; sternotomy, $n=26$; and thoracotomy, $n=10$) and 94 in the post-liposome bupivacaine group (laparotomy, $n=49$; sternotomy, $n=31$; and thoracotomy, $n=14$). Of the laparotomy patients in the post-liposome bupivacaine group, eleven received a CTE anesthesia and 38 did not. Of the laparotomy patients in the pre-liposome bupivacaine group, 18 received CTE anesthesia and 34 did not.

Table 2 Demographic and baseline clinical characteristics

Characteristic	Pre-liposome bupivacaine (n=88)	Post-liposome bupivacaine (n=94)
Mean age, years (SD)		
Overall population	54 (18)	55 (16)
Laparotomy ^a	50 (18)	56 (16)
CTE	50 (17)	60 (15)
No CTE	50 (20)	55 (17)
Sternotomy ^b	62 (12)	58 (13)
Thoracotomy ^c	55 (22)	45 (20)
Male sex, n (%)		
Overall population	52 (59)	48 (51)
Laparotomy ^a	25 (48)	16 (33)
CTE	9 (36)	3 (19)
No CTE	16 (64)	13 (81)
Sternotomy ^b	19 (73)	23 (74)
Thoracotomy ^c	8 (80)	9 (64)
ASA physical status classification, mean (SD)		
Overall population	2.6 (0.7)	2.7 (0.7)
Laparotomy ^a	2.4 (0.7)	2.6 (0.7)
CTE	2.5 (0.5)	2.6 (0.5)
No CTE	2.4 (0.7)	2.6 (0.8)
Sternotomy ^b	3.2 (0.4)	2.9 (0.6)
Thoracotomy ^c	2.4 (0.7)	2.3 (0.6)
Preoperative pain score, mean (SD)		
Overall population	2.0 (2.9)	0.7 (1.9) ^d
Laparotomy	2.8 (3.3)	1.3 (2.5) ^e
CTE	1.6 (2.4)	2.9 (3.4)
No CTE	3.5 (3.5)	0.8 (2.0)
Sternotomy	0.9 (1.8)	0 ^e
Thoracotomy	0.6 (1.9)	0.4 (1.3)
Preoperative NRS pain intensity score ≥ 7 , n (%)	9 (10)	2 (2)

Notes: ^aData shown are based on subgroups: n=52 for the pre-liposome bupivacaine group and n=49 for the post-liposome bupivacaine group. ^bData shown are based on subgroups: n=26 for the pre-liposome bupivacaine group and n=31 for the post-liposome bupivacaine group. ^cData shown are based on subgroups: n=10 for the pre-liposome bupivacaine group and n=14 for the post-liposome bupivacaine group. ^dP=0.001 vs pre-liposome bupivacaine group. ^eP<0.01 vs pre-liposome bupivacaine group.

Abbreviations: ASA, American Society of Anesthesiologists; CTE, continuous thoracic epidural; NRS, numerical rating scale; SD, standard deviation.

Patient demographic and baseline clinical characteristics are summarized in Table 2. The groups were relatively well matched at baseline, with the exception of preoperative pain scores, which were significantly lower in the overall post-liposome bupivacaine group, as well as in the laparotomy and sternotomy subgroups. A greater proportion of patients had severe pain (NRS score ≥ 7) preoperatively during the pre-liposome bupivacaine period (10% [9/88]) compared with patients who underwent surgery during the post-liposome bupivacaine period (2% [2/94]).

Results for overall groups

Mean (standard deviation [SD]) pain scores during the first 72 hours after surgery were similar in the pre-liposome bupivacaine group (2.3 [1.2]) compared with the post-liposome

bupivacaine group (2.3 [1.8]; $P=0.33$). However, the mean (SD) highest pain score was significantly higher in the pre-liposome bupivacaine group (7.1 [2.3]) than in the post-liposome bupivacaine group (6.2 [2.6]; $P=0.007$).

Mean (SD) amounts of opioids (oral morphine equivalents) consumed were similar in the pre- and post-liposome bupivacaine groups (291 [309] vs 263 [227] mg; $P=0.64$). Mean (SD) duration of ICU stay was also similar in the two treatment groups (1.9 [2.1] vs 1.8 [2.1] days; $P=0.61$), but mean (SD) duration of hospital stay was more than a full day longer in the pre-liposome bupivacaine group (7.0 [3.4] days) than in the post-liposome bupivacaine group (5.8 [2.7] days; $P=0.009$).

Results for subgroups stratified by type of surgery

Mean pain scores, postsurgical opioid use, and lengths of ICU and hospital stay results are summarized in Table 3. In patients who underwent laparotomy, mean length of hospital stay was significantly shorter in the post-liposome bupivacaine group (5.8 days) compared with the pre-liposome bupivacaine group (7.4 days; $P=0.027$). In patients who underwent sternotomy, the mean maximum postsurgical pain intensity score was significantly lower in the post-liposome bupivacaine group (5.7) compared with the pre-liposome bupivacaine group (7.2; $P=0.039$). No other statistically significant between-group differences were observed. However, there was a trend toward reduced postsurgical opioid use in the post-liposome bupivacaine group in the subset of patients who underwent laparotomy (232 vs 345 mg of oral morphine equivalents in the post- and pre-liposome bupivacaine groups, respectively; $P=0.059$), and a trend toward increased opioid use in the post-liposome bupivacaine group in the subset that underwent sternotomy (254 vs 192 mg of oral morphine equivalents in the post- and pre-liposome bupivacaine groups, respectively; $P=0.051$).

Results for subset analyses of laparotomy patients

Results for mean pain scores, postsurgical opioid use, and lengths of ICU and hospital stays for laparotomy patients stratified by pain control method are summarized in Table 4. On average, length of hospital stay was significantly shorter (by ~ 1 day; $P=0.028$) in patients who received CTE anesthesia during the period when liposome bupivacaine was available compared with the time period before liposome bupivacaine became available.

An analysis of data from the pre-liposome bupivacaine period showed that patients who received CTE anesthesia

Table 3 Results for subgroups stratified by type of surgery

Parameter	Laparotomy		Sternotomy		Thoracotomy	
	Pre-liposome bupivacaine (n=52)	Post-liposome bupivacaine (n=49)	Pre-liposome bupivacaine (n=26)	Post-liposome bupivacaine (n=31)	Pre-liposome bupivacaine (n=10 ^a)	Post-liposome bupivacaine (n=14)
Mean pain intensity score	2.2	2.4	2.3	2.1	2.5	2.3
Mean maximum pain intensity score	7.0	6.4	7.2	5.7 ^b	6.7	6.4
Mean total amount of orally administered postsurgical opioids (milligram morphine equivalents)	345	232	192	254	268	394
Number of patients admitted to ICU, n (%)	18 (35)	19 (39)	26 (100)	30 (97)	10 (100)	10 (71)
Mean length of ICU stay (days)	1.0	0.8	3.8	3.3	1.7	2.1
Mean length of hospital stay (days)	7.4	5.8 ^b	6.6	6.0	6.0	5.1

Notes: ^aPatients received continuous infusion of local anesthetic via elastomeric pump. ^b $P < 0.05$ vs pre-liposome bupivacaine group.

Abbreviation: ICU, intensive care unit.

had significantly longer mean ICU stays and longer mean hospital stays than patients who did not receive CTE anesthesia ($P < 0.05$ for both comparisons; Table 4). However, those who received CTE anesthesia reported lower mean pain intensity scores ($P = 0.037$).

Among patients who underwent laparotomy during the period when liposome bupivacaine was available, those who received liposome bupivacaine had a significantly shorter mean duration of ICU and hospital stay than those who received CTE anesthesia ($P < 0.05$ for both comparisons; Table 4). No statistically significant between-group differences were observed in mean pain scores or amount of mean postsurgical oral opioids consumed in these two patient subsets.

Discussion

Local anesthetic wound infiltration and TAP block are gaining acceptance as simple and effective techniques to

manage postoperative pain following a variety of open and laparoscopic procedures.^{22–24} Wound infiltration analgesia is typically administered as a single injection at the end of an operation while patients are under general or regional anesthesia,²² while TAP block is injected into the neurovascular plane of the abdominal musculature.²⁵ Multimodal analgesia regimens that include wound infiltration or TAP blocks with local anesthetics are reported to be associated with decreased postoperative pain scores, reduced opioid consumption, fewer ORAEs, earlier patient mobility, shorter hospital stays, and greater patient satisfaction compared with other pain management strategies.^{22,23,26–28} Side effects and surgical complications are infrequent, and systemic toxicity is rare with TAP block or wound infiltration of local anesthetics; in contrast, epidural approaches can be associated with unwanted motor blockade, bladder dysfunction, and other potentially serious complications.^{24,26,27,29–33} In addition, local infiltration and TAP block techniques are easier to administer

Table 4 Results for subset analyses of patients who underwent laparotomy

Parameter	Laparotomy			
	Pre-liposome bupivacaine, CTE (n=18)	Pre-liposome bupivacaine, No CTE (n=34)	Post-liposome bupivacaine, CTE only (n=11)	Post-liposome bupivacaine, liposome bupivacaine only (n=38)
Mean pain intensity score	1.6	2.6 ^a	2.4	2.5
Mean maximum pain intensity score	6.2	7.4	7.1	6.2
Mean total amount of orally administered postsurgical opioids (milligram morphine equivalents)	242	400	226	234
Mean length of ICU stay (days)	1.7	0.7 ^b	1.5	0.6 ^c
Mean length of hospital stay (days)	8.9	6.6 ^d	7.7 ^e	5.3 ^f

Notes: ^a $P = 0.037$ vs laparotomy pre-liposome bupivacaine CTE group. ^b $P = 0.04$ vs laparotomy pre-liposome bupivacaine CTE group. ^c $P = 0.02$ vs laparotomy post-liposome bupivacaine CTE only group. ^d $P = 0.03$ vs laparotomy pre-liposome bupivacaine CTE group. ^e $P = 0.028$ vs laparotomy pre-liposome bupivacaine CTE group. ^f $P = 0.03$ vs laparotomy post-liposome bupivacaine CTE only group.

Abbreviations: CTE, continuous thoracic epidural; ICU, intensive care unit.

than epidural analgesia and do not require special expertise to perform.^{23,30} TAP blocks can also be used for patients undergoing major surgery who have contraindications to epidural analgesia (eg, those with clotting disorders or sepsis).^{27,28} Based on these findings from the medical literature, we postulated that incorporating liposome bupivacaine into multimodal analgesia regimens for postsurgical pain management at NMCS D could result in CQI at our facility. This retrospective chart review was undertaken to compare postsurgical outcomes before and after liposome bupivacaine became available at NMCS D.

Findings from our analysis suggest that overall, the quality of postsurgical analgesia (mean pain intensity scores and amounts of orally administered opioids consumed) was similar during the pre- and post-liposome bupivacaine periods, but the average length of hospital stay was significantly shorter during the post-liposome bupivacaine period. This difference was apparently driven by the between-group difference in the laparotomy surgery subgroups, which represent the largest patient populations in the study. The number of patients included in the sternotomy and thoracotomy surgery treatment groups may have been too small to show statistically significant differences on this parameter.

Interestingly, the use of CTE anesthesia decreased after liposome bupivacaine became available at NMCS D. During the pre-liposome bupivacaine period, 35% (18/52) of patients received CTE anesthesia compared with 22% (11/49) of patients during the post-liposome bupivacaine period. This is noteworthy because of the potential safety concerns associated with the use of CTE anesthesia (eg, spinal hematoma, abscess, and permanent neurologic damage).³³ Avoiding the use of CTE anesthesia can be particularly useful in cases wherein anticoagulation, ambulation requirements, hemodynamic concerns, or inpatient epidural management requirements may preclude the use of epidurals.^{33–35} Some anesthesiologists have indicated that they are performing fewer epidural procedures, in large part due to fear of litigation and lack of evidence supporting clinical benefits compared with other less-invasive pain management strategies.³³ Analgesic techniques that allow for avoidance of continuous infusion modalities and/or are associated with shorter hospital stays may lead to decreased health care costs. While formal cost analyses were not conducted in this study, even a 1-day reduction in hospital stay would be expected to result in significant cost savings. Based on data from a recent survey of clinicians and economic professionals from US hospitals, the average hospital cost per day following inpatient general/colorectal surgery is ~US\$2,000.³⁶

Findings from the same survey³⁶ indicate that the estimated average direct cost per hospital stay for a patient who uses intravenous opioid patient-controlled analgesia is ~\$600, plus an average of ~4 hours of staff time associated with administration, documentation, and monitoring. The direct cost associated with continuous infusion of local anesthetics via elastomeric pumps is ~\$650 per patient plus ~3 hours of staff time associated with administration, documentation, and monitoring, while the direct cost of a 266 mg/20 mL vial of liposome bupivacaine is ~\$300. Assuming that a similar level of analgesia is achieved with each modality, use of liposome bupivacaine could lead to meaningful cost savings (~\$300 per patient or \$300,000 per 1,000 patients). Furthermore, findings from a series of open-label economic studies support the use of liposome bupivacaine-based multimodal analgesic regimens over intravenous opioid-based regimens for postsurgical analgesia in patients undergoing open colectomy,³⁷ laparoscopic colectomy,³⁸ and ileostomy reversal.^{39,40} A pooled analysis of data from the 191 patients (liposome bupivacaine-based multimodal analgesia, n=86; intravenous opioid-based analgesia, n=105) across these studies showed that the multimodal analgesia group had significantly less mean postsurgical opioid consumption (38 vs 96 mg morphine equivalents; $P<0.0001$), shorter median hospital length of stay (2.9 vs 4.3 days; $P<0.0001$), and lower mean hospitalization costs (\$8,271 vs \$10,726; $P=0.011$), compared with intravenous opioid-based analgesia.¹⁶

There are several limitations to the interpretation of results from our analysis. The study was inherently limited by its retrospective observational design, which could not control for possible selection bias (eg, sicker/more complex patients may have been more likely to receive CTE anesthesia than healthier patients). Moreover, the results were derived from patients who were treated at a single institution; our observations may not be generalizable to other institutions or patient populations. Finally, there are several potential factors other than the intervention studied that could have contributed to the observed results (eg, other improvements in surgical or postoperative practices may have occurred between December 2011 and May 2014, which could have influenced the results). It should also be noted that although the characteristics of the patient groups treated during the pre- and post-liposome bupivacaine periods of the study were generally similar, mean preoperative pain intensity scores were significantly higher in the pre-liposome bupivacaine group (2.0) compared with the post-liposome bupivacaine group (0.7; $P=0.001$). This difference was primarily driven by a higher number of outliers in the post-liposome bupivacaine group. Larger, prospective,

controlled studies are needed to confirm the reproducibility of these findings across a heterogeneous range of patient populations and surgical practices.

Conclusion

This analysis allowed us to observe how our surgeons and anesthesiologists have changed the way they manage postoperative pain after liposome bupivacaine was introduced at NMCS. Since the time point that liposome bupivacaine became available, there has been a noticeable decrease in the use of CTE anesthesia. Given the relative simplicity of administration and the seemingly comparable efficacy for postsurgical analgesia, liposome bupivacaine may be a useful alternative to epidural anesthesia.

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Disclosure

The authors report no conflicts of interest in this work.

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