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Continuous Intraoperative Epidural Infusions Affect Recovery Room Length Of Stay And Analgesic Requirements: A Single-Center Observational Study

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Abstract

PURPOSE—Continuous intraoperative epidural analgesia may improve post-operative pain control and decrease opioid requirements. We investigate the effect of epidural infusion initiation before or after arrival in the post-anesthesia care unit on recovery room duration and post-operative opioid use.

METHODS—We performed a retrospective chart review of abdominal, thoracic and orthopedic surgeries where an epidural catheter was placed prior to surgery at the University of Washington Medical Center during a 24 month period.

RESULTS—Patients whose epidural infusions were started prior to PACU arrival (Group 2: n=540) exhibited a shorter PACU length of stay ($p=.004$) and were less likely to receive intravenous opioids in the recovery room (34% vs. 48%; $p<.001$) compared to patients whose infusions were started after surgery (Group 1: n=374). Although the highest patient-reported pain scores were lower in Group 2 (5.3 vs. 6.0; $p=.030$), no differences in the pain scores prior to PACU discharge were observed.

CONCLUSION—Intraoperative continuous epidural infusions decrease PACU LOS as discharge criteria for patient-reported NRS pain scores are met earlier.

Keywords

Pre-emptive analgesia; Continuous epidural analgesia; Post-operative pain control

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INTRODUCTION

Epidural infusions decrease post-surgical pain [1,2] and reduce IV opioid consumption and opioid-induced hyperalgesia. [3–6] Other purported benefits include modulation of the central desensitization that occurs with continued nociceptive inputs from surgical stimulation while under general anesthesia. [7] A potential consequence of delayed or omitted epidural infusion initiation is the additional required intravenous opioid analgesics to treat breakthrough post-operative pain, which is associated with an increased incidence of opioid related side effects such as nausea, vomiting and pruritus. [8] While previous studies have explored the utility of pre-emptive epidural catheter boluses prior to surgical incision to decrease post-operative pain, no study has evaluated the benefit of continuous intraoperative epidural infusions on recovery room duration and opioid use in the immediate post-operative period.

A review of our practice, prompted by a quality improvement project focused on workflow interventions aimed to increase the rate of successful intraoperative epidural infusion initiation, found that only 57% of epidural catheters placed prior to surgery were actually used during the surgery, many of them running for less than half of the procedure duration. [9] Reasons for delayed or failed epidural initiation included the complex process involving multiple teams, such as pharmacy, materials management and regional anesthesia teams to place and start the epidural infusion. [10] Furthermore, intraoperative epidural infusion is often stopped as a first step when treating hypotension and subsequently not restarted until arrival in the recovery room.

In the present study, the main objective was to evaluate the effect of intra-operative epidural infusion on selected recovery room outcomes such as length of stay, reported pain scores and analgesic use. To this end, we reviewed all elective, non-obstetric procedures that received an epidural catheter placed prior to surgery over a 2-year period at a large academic medical center. We hypothesize that outcomes would be improved in cases during which the epidural catheter was infusing during the majority of the operation.

METHODS

After receiving approval from the University of Washington Institutional Review Board, we retrospectively searched our institution's electronic health record database for all cases associated with epidural placement prior to the procedure. Data collection and quality assurance was undertaken and verified by two study authors (A.S., B.N.) We included all non-obstetric cases from October 2012 until October 2014 in adult patients (> 18 years), scheduled for elective surgery at our institution. We excluded cases with subsequent intraoperative cancellations (e.g. prior to surgical incision or instrumentation), procedure duration shorter than 90 minutes, and missing data regarding primary outcomes. In addition, procedures where an intravenous (IV) patient-controlled analgesia (PCA) delivery system was ordered in combination with an only local anesthetic containing epidural infusion (split epidural) were excluded from the analysis.

Patients were grouped according to their intraoperative epidural infusion duration as follows:

1. Group 1 included admissions where the epidural infusion was not started intra-operatively (No Infusion Group).
2. Group 2 included admissions where the epidural infusion was used (Yes Infusion Group).

Epidural catheters were placed in the pre-operative holding area by a dedicated regional anesthesia team or by the cardiothoracic anesthesia service, both consisting of a senior resident supervised by an attending physician. After successful placement, catheter location was tested with 3 ml of 1.5% lidocaine containing 1:200,000 epinephrine, per routine care. Appendix Table 1 lists the epidural infusion solutions used in patients receiving intraoperative epidural infusions (Group 2), which are delivered to the operating room suite and started at the discretion of the anesthesiologist during surgery or in the recovery room (post-anesthesia care unit; PACU). All patients received a general anesthetic (i.e. with desflurane and sevoflurane) with an endotracheal tube. Their anesthetic was initially titrated to 1 MAC and further adjusted based on patient responsiveness and hemodynamics.

Upon arrival in the PACU, a dedicated pain management team evaluates epidural function de novo and manages the infusion rate and concentration adjustments, if needed. If possible, all patients receive a dose of IV or oral non-steroidal anti-inflammatory drug (NSAID) and/or acetaminophen.

Data Collection

Anesthesia Information Management System (AIMS)—The AIMS database has been used for several previous studies. [11] Our department submits data to the Multicenter Perioperative Outcome Group (MPOG - <http://www.mpogresearch.org/>) on a regular basis from our AIMS database and as part of this submission we validate data quality and accuracy. Additionally for this study, we verified data extracted from the AIMS database against source records (anesthesia and other medical records) in a subset of 25 randomly selected cases.

Covariates—Demographic information for each patient was collected directly from the electronic medical record. For each patient, we noted the risk factors for poor post-operative pain control, including chronic opioid or sedative use, a history of substance abuse, complex surgery (i.e. intrathoracic or intra-abdominal approach), and obstructive sleep apnea. [1,12,13,14] Epidural information was obtained from the procedure note. Information regarding intraoperative medications, infusion status, and procedure and infusion start times were obtained from the anesthesia record. Surgical start and stop times are routinely recorded in the anesthesia record and were used to calculate surgical duration.

Outcomes—PACU length-of-stay (LOS) was obtained from the recovery room charts in the electronic medical record for each procedure. At our institution, we utilize pain management guidelines to guide discharge from the PACU, which requires that patients must be monitored in the PACU for a minimum of 1) 60 minutes after epidural infusion has been started, and 2) 30 minutes after the last IV opioid has been administered. Data for patients whose LOS was affected by systems factors including low bed availability, delays

due to nursing assignment or patient transportation delay, and absence of discharge orders were excluded from the analysis. Intra- and post-operative IV opioid consumption was obtained from the anesthesia record and electronic medical record, respectively. Fentanyl consumption was recorded post-intubation. We considered IV hydromorphone and morphine as “long-acting” opioids for the purposes of this study. All opioids were converted to oral morphine equivalents (OME) and summated in order to standardize reporting amongst patients receiving different types of opioids (i.e. IV fentanyl 200 mcg = IV hydromorphone 3 mg = IV morphine 20 mg = oral morphine 60 mg).

We obtained patient-reported pain scores using the 11-point numeric rating scale (Numeric Rating Scale, NRS; 0–10) [15] at three different time points during the recovery room stay (post-anesthesia care unit; PACU):

1. The first NRS pain score (FIRST) was recorded upon PACU entry.
2. The last NRS pain score: (LAST) was the recorded before patients were discharged from the PACU.
3. The maximum NRS pain score (MAX) was the highest reported pain score measured during the recovery period.

Statistics

We conducted univariate analyses to compare groups with regards to demographics, procedure characteristics, and outcomes. For unadjusted comparisons we used ANOVA, Mann-Whitney U, or Pearson Chi-square tests depending on whether the variable compared over groups was continuous, ordered categorical, or categorical, respectively. We compared IV opioid consumption, PACU LOS, and NRS pain scores between epidural groups using linear regression to adjust for potential confounders. Proportions of patients who had any post-operative IV opioid consumption were compared between groups using logistic regression to adjust for potential confounders. An additional linear regression model for the PACU LOS outcome was computed evaluating the association between PACU LOS and the proportion for the procedure time for which the epidural infusion was active. The post-operative IV opioid consumption and pain score models were adjusted for patient age, gender, weight, presence of any chronic pain risk factor, intraoperative opioid administration, procedure type (abdominal, thoracic, other), ASA code and procedure duration. The PACU LOS models contained these adjustors as well as any anti-emetic medication use. Pain risk factors considered included chronic opioid use, complex surgery, current use of sedatives, history of difficult pain control or substance abuse, and obstructive sleep apnea (OSA). Interactions between procedure type and epidural group were evaluated for all outcomes. Prior to regression analyses, IV opioid consumption and the PACU LOS values were log-transformed, which satisfied normality assumptions as well as facilitated comparisons on a relative, rather than absolute, scale, which we considered most appropriate for these outcomes. The means presented for IV opioid consumption and LOS are geometric means in the original scale. We calculated two-sided p-values and deemed a value less than alpha of 0.05 to be statistically significant. Data were analyzed with IBM SPSS Statistics for Windows (Version 19.0, IBM Corp., Armonk, NY).

RESULTS

I. Baseline Characteristics

Between October 2012 and October 2014, we identified 2371 elective procedures performed on patients receiving pre-operative epidural catheters for post-operative pain control. We excluded 100 cases with procedure duration < 90 minutes, 573 cases with a combination of epidural and PCA regimen, 104 cases without any epidural opioid (i.e. plain local anesthetic solution), 5 cases that were cancelled after induction, 172 duplicate cases (only the most recent procedure was included), 321 cases with missing PACU LOS data, and 182 cases with missing data regarding post-operative IV opioid administration.

Of these 914 cases composing the study population, the epidural infusion was not started until after the surgery in 374 procedures (40.9%) (Group 1). Epidural infusions were started in the OR in 540 procedures (59.1%) (Group 2).

Demographics and surgical characteristics are presented for the entire cohort in Table 1. In the study cohort, there was a greater proportion of female versus male patients, and more abdominal procedures compared to thoracic procedures. A total of 329 patients (36.0%) had at least one post-operative pain risk factor. There was a greater proportion of thoracic procedures in Group 1 compared to Group 2. There were no statistically significant differences among patient demographics or the prevalence or chronic pain risk factors between groups.

II. Recovery Room Length-of-Stay (LOS)

376 procedures were excluded from the LOS analysis due to delays unrelated to the patient's condition prior to transfer to an inpatient ward. Group 2 patients exhibited a shorter LOS compared to Group 1 patients (141 min. vs. 161 min., $p=.002$). In an adjusted regression model, Group 2 patients demonstrated a significantly shorter LOS compared to Group 1 patients (12 % shorter mean LOS, 95% CI: 4–19%; $p=.004$). (Table 2a)

When considered as a continuous variable, epidural infusion duration (as a proportion of total procedure duration) demonstrated a statistically significant negative linear association with PACU LOS (unadjusted $p < 0.001$). (Figure 1) After adjustment for age, gender, weight, ASA classification, chronic pain risk factors, intraoperative opioid administration, procedure type and procedure duration, an increase in epidural infusion duration of 50% of the procedure was found to be associated with a 10.1% decrease in mean PACU LOS ($p=.001$) Figure 2 demonstrates the effect of the time of epidural infusion initiation, relative to procedure start time, on PACU LOS in Group 2 patients. There was a statistically insignificant trend towards a shorter PACU LOS with epidural infusions that were started earlier in the intraoperative course (i.e. just prior to or soon after the start of the procedure) ($p=.098$)

III. Intravenous Opioid Use

There were no group differences regarding the intraoperative administration of one or more doses of long-acting IV opioids (hydromorphone, morphine) (Group 2 vs. Group 1: 53% vs.

50%; $p=.659$). Group 2 patients received IV fentanyl more frequently than patients in Group 1 (86% vs. 80%; $p=.015$), and thus received any opioid (fentanyl or long-acting opioid) at a significantly higher frequency (95% vs 91%; $p=.022$) (Table 3). However, there were no differences regarding the cumulative intraoperative administration of opioids between the two groups.

Table 2b lists the proportions of patients in each epidural group who received one or more doses of any IV opioid in the PACU, as well as comparisons adjusting for demographic and procedural characteristics. In the adjusted model, Group 2 patients were less likely to receive any dose of IV opioid (fentanyl, hydromorphone, morphine) in the PACU compared to Group 1 patients (39% decrease in frequency of any dose of IV opioid, 95% CI: 20%–54%; $p<.001$). The administration of one or more doses of fentanyl was significantly lower in Group 2 compared to Group 1 ($p=.01$), while there was no statistically significant difference in the administration of long-acting IV opioid (e.g. hydromorphone, morphine) between the Groups. For patients who did receive one or more IV opioid doses in PACU Group 2 patients had a slightly higher overall opioid consumption (Oral Morphine Equivalents; OME) (Table 2c) compared to Group 1 patients, although this was not statistically significant ($p=.065$).

IV. Patient-Reported Pain Scores

NRS data were available in 820 patients (Group 1: $n = 340$ patients; Group 2: $n = 480$ patients). (Table 4) After adjustment for potential confounders (age, gender, any pain risk factors, procedure type, procedure duration and ASA code), there was a slightly lower MAX pain score in Group 2 vs. Group 1 patients ($p=.030$). No statistically significant associations were identified between the groups with respect to FIRST or LAST pain scores.

DISCUSSION

To the best of our knowledge, this is the first study evaluating the impact of intraoperative epidural infusion duration on recovery room length of stay (PACU LOS) and recovery room opioid requirements. The literature on pre-emptive analgesia includes studies focusing on a single pre-incisional epidural injection, with mixed results. Some authors report reduced VAS scores at rest and with activity (e.g. coughing) as well as decreased analgesic requirements after pre-emptive epidural boluses. [2,16–18] Other studies have questioned the pre-emptive impact of epidural bolus therapy on post-operative pain scores. [19–22] Similarly, Aguilar et al. demonstrated no difference in resting and active pain scores when administering 0.5% bupivacaine before or after incision in their cohort of thoracotomy patients. [23] We retrospectively analyzed effects of intraoperative epidural infusion initiation on post-operative pain-related outcomes. Specifically, we compared postoperative outcome in between patients whose epidural infusions were started in the operating room versus patients whose epidural infusions were not started until the PACU or thereafter.

The main finding of our study is that patients receiving an intraoperative epidural infusion (Group 2) had a significantly shorter PACU LOS, even with similar use of intraoperative opioid therapy between the groups. This finding may be due to decreased intraoperative anesthetic requirements (e.g. volatile anesthetic), thereby decreasing the incidence and duration of post-operative sedation. Thus, Group 2 patients are likely to report pain scores

early on during their PACU phase and meet criteria for PACU discharge earlier than Group 1 patients. stay in the recovery room [24–25] Ramifications of this finding include the omission of opioid-related discharge delays from the recovery room, as many studies have identified nausea and vomiting as risk factors for a prolonged PACU stay. [10,25] Shortening the recovery period, as well as using less opioids in the recovery room, conveys multiple benefits for patients and healthcare systems alike, including a reduction of the aforementioned opioid-induced side effects, their respective treatments in addition to a reduction of service fees for patients, which often outweigh expenses incurred on inpatient floors. [25]

NRS data in the PACU did not significantly vary among groups. FIRST NRS scores were similar between groups, a finding which could be attributed to residual sedation affecting the accuracy of the reported pain score, when assessed by the PACU RN or to effective intraoperative analgesia. Group 2 patients may recover at a faster pace from anesthesia and thus report higher-than-expected FIRST NRS scores compared to Group 1 patients. The highest pain score reported in the recovery room was statistically lower in Group 2 patients by less than a point. This difference, however, is of limited clinical significance. Moreover, the average LAST reported NRS was below a score of 4 and not significantly different between the groups which is in agreement with institutional PACU discharge criteria. PACU pain management was subsequently provided using a multimodal approach when possible according to institutional guidelines [26], including IV or PO NSAIDs and or acetaminophen when indicated. While previous studies have yielded positive findings with respect to decreased VAS scores and IV opioid consumption, most of these studies have focused on outcomes at later time points (e.g. 24–72 hours after surgery). [2,15,27] Thus, we considered pain scores to be a “targeted index” to which a provider targets intraoperative multimodal analgesic therapy (i.e. to satisfy a certain threshold such as 4 or less), rather than a true outcome measure of pain management efficacy.

Patients receiving intraoperative epidural infusions (Group 2) were less likely to receive any opioids in the PACU, even after correction for intraoperative opioid administration as well as chronic opioid use, a common comorbidity in our population that influences PACU opioid management [28]. However, a few patients in Group 2 still required significant amounts of IV opioids in the PACU, blunting an expected difference of decreased post-operative IV opioid consumption in this group. This finding may be explained by the heterogeneity of surgeries, partial epidural failures with some dermatomal spread/wound area mismatch requiring IV opioid breakthrough pain management, or postoperative hypotension precluding effective epidural analgesia. While ineffective or inadequate analgesia are complications of neuraxial procedures portending increased opioid usage, at our institution, all catheters are tested for sensory analgesia level after placement and again after the operation by the acute pain service consultants, once the patient has sufficiently recovered from anesthesia. Epidural catheters that require troubleshooting are then de-novo tested with a local anesthetic bolus and/or manipulated by the acute pain service (e.g. catheter pulled back or replaced entirely). In some cases, the pain service will change the epidural rate or local anesthetic concentration, or transfer the epidural opioid to the IV route using a PCA pump, yielding a “split” epidural.

We recognize certain limitations within our study. The results presented here are derived from the experience at a single academic center and thus any generalization must be done with caution. There is no current standardized protocol for starting the epidural at a specific time during or after the case, and the decision is left to the discretion of the anesthesiologist. Findings from a previous quality improvement project suggest that the initiation of epidural infusions is postponed due to delays in infusate preparation, or concerns for ongoing intraoperative blood loss or hypotension. Multiple risk factors for postoperative pain in the recovery room can confound the value of epidural interventions on pain-related outcomes. For example, a single-center study of more than 100,000 anesthetics found that younger patients, female gender and ASA class III or below were more likely to report higher VAS scores. [29] There are possibilities for additional confounders, especially pertaining to procedure duration and PACU opioid requirements, due to the various types of surgeries included. We considered abdominal and thoracic cases separately in stratified analyses, but saw no differences from the patterns observed in the overall cohort. To this end, we based analyses on the combined cohort and adjusted for group differences that were discovered during univariate comparisons of the two groups. We did not collect data on PACU epidural local anesthetic boluses. Finally, we excluded procedures associated with immediate post-operative PCA use because of the inability to reliably extract data from the PACU PCA pumps.

CONCLUSION

In summary, our main finding purports that continuous intraoperative epidural infusions decrease recovery room times as discharge criteria for patient-reported NRS pain scores are met earlier. This finding is associated with reduced post-operative opioid use. Further studies are warranted to corroborate and prospectively validate these results in specific surgical populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Kehlet H, Jensen TS, Woolf CJ. Persistent postsurgical pain: risk factors and prevention. *Lancet*. 2006; 367:1618–25. [PubMed: 16698416]
2. Andrae MH, Andrae DA. Local anaesthetics and regional anaesthesia for preventing chronic pain after surgery. *Cochrane Database Syst Rev*. 2012; 10:CD007105. [PubMed: 23076930]
3. Block BM, Liu SS, Rowlingson AJ, Cowan AR, Cowan JA, Wu CL. Efficacy of postoperative epidural analgesia: a meta-analysis. *J Am Med Assoc*. 2003; 290:2455–63.
4. Ong CK, Lirk P, Seymour RA, Jenkins BJ. The efficacy of preemptive analgesia for acute postoperative pain management: a meta-analysis. *Anesth Analg*. 2005; 100:757–73. [PubMed: 15728066]

5. Wheatley RG, Schug SA, Watson D. Safety and efficacy of postoperative epidural analgesia. *Br J Anaesth.* 2001; 87:47–61. [PubMed: 11460813]
6. Rivat C, Bollag L, Richebé P. Mechanisms of regional anaesthesia protection against hyperalgesia and pain chronicization. *Current Opin Anaesthesiol.* 2013; 26:621–5.
7. Woolf CJ, Chong MS. Preemptive analgesia – treating postoperative pain by preventing the establishment of central sensitization. *Anesth Analg.* 1993; 77:362–79. [PubMed: 8346839]
8. Roberts GW, Bekker TB, Carlsen HH, Moffatt CH, Slattery PJ, McClure AF. Postoperative nausea and vomiting are strongly influenced by postoperative opioid use in a dose-related manner. *Anesth Analg.* 2005; 101:1343–8. [PubMed: 16243992]
9. McGauvran, M., Shah, AC., Nair, BG., Bollag, L. Proceedings of the International Anesthesia Research Society. Honolulu, HI: Mar 21–24. 2015 Process improvements to improve initiation of epidural infusion times and decrease PACU pain scores. Abstract S530
10. Hibbard FJ, Bosso JA, Sward LW, Baum S. Delivery time in a decentralized pharmacy system without satellites. *Am J Hosp Pharm.* 1981; 38:690–2. [PubMed: 7282699]
11. Nair BG, Grunweig K, Peterson GN, Horibe M, Neradilek MB, Newman SF, Van Norman G, Schwid HA, Hao W, Hirsch IB, Patchen Dellinger E. Intraoperative blood glucose management: impact of a real-time decision support system on adherence to institutional protocol. *J Clin Monit Comput.* 2016; 30:301–12. [PubMed: 26067402]
12. Cron DC, Englesbe MJ, Bolton CJ, Joseph MT, Carrier KL, Moser SE, Waljee JF, Hilliard PE, Kheterpal S, Brummett CM. Preoperative Opioid Use is Independently Associated With Increased Costs and Worse Outcomes After Major Abdominal Surgery. *Ann Surg.* 2016 Jul 15. [Epub ahead of print].
13. Caumo W, Nazare Furtado da Cunha M, Camey S, Maris de Jesus Castro S, Torres IL, Cadore Stefani L. Development, psychometric evaluation and validation of a brief measure of emotional preoperative stress (B-MEPS) to predict moderate to intense postoperative acute pain. *Br J Anaesth.* 2016; 117:642–9. [PubMed: 27799179]
14. Fassbender P, Herbstreit F, Eikermann M, Teschler H, Peters J. Obstructive Sleep Apnea-a Perioperative Risk Factor. *Dtsch Arztebl Int.* 2016; 113:463–9. [PubMed: 27476705]
15. 0–10 Numeric rating scale [Internet]. Bethesda (MD): Warren Grant Magnuson Clinical Center; 2003. National Institutes of Health, Warren Grant Magnuson Clinical Center (UW) Pain intensity instruments. July 2003. Available at <http://www.mvlta.net/Presentations/mvlta.pdf>
16. Wu CT, Yeh CC, Yu JC, Lee MM, Tao PL, Ho ST, Wong CS. Pre-incisional epidural ketamine, morphine and bupivacaine combined with epidural and general anaesthesia provides pre-emptive analgesia for upper abdominal surgery. *Acta Anaesthesiol Scand.* 2000; 44:63–8. [PubMed: 10669274]
17. Gottschalk A, Smith DS, Jobes DR, Kennedy SK, Lally SE, Noble VE, Grugan KF, Seifert HA, Choung A, Malkowicz SB, Gutsche BB, Wein AJ. Preemptive epidural analgesia and recovery from radical prostatectomy: a randomized controlled trial. *J Am Med Assoc.* 1998; 279:1076–82.
18. Amr YM, Yousef AA, Alzeftawy AE, Mossbah WI, Saber AM. Effect of preincisional epidural fentanyl and bupivacaine on postthoracotomy pain and pulmonary function. *Ann Thorac Surg.* 2010; 89:381–5. [PubMed: 20103303]
19. Dahl JB, Hansen BL, Hjortso NC, Erichsen CJ, Moiniche S, Kehlet H. Influence of timing on the effect of continuous extradural analgesia with bupivacaine and morphine after major abdominal surgery. *Br J Anaesth.* 1992; 69:4–8. [PubMed: 1637601]
20. Espinet A, Henderson DJ, Faccenda KA, Morrison LMM. Does pre-incisional thoracic extradural block combined with diclofenac reduce postoperative pain after abdominal hysterectomy. *Br J Anaesth.* 1996; 76:209–13. [PubMed: 8777099]
21. Richards JT, Read JR, Chambers WA. Epidural anaesthesia as a method of pre-emptive analgesia for abdominal hysterectomy. *Anaesthesia.* 1998; 53:296–8. [PubMed: 9613276]
22. Burmeister MA, Gottschalk A, Freitag M, Horn EP, Böhme C, Becker C, Standl TG. Pre- and intraoperative epidural ropivacaine have no early preemptive analgesic effect in major gynecological tumour surgery. *Can J Anaesth.* 2003; 50:568–73. [PubMed: 12826548]
23. Aguilar JL, Cubells C, Rincon R, Preciado MJ, Valldeperas I, Vidal F. Pre-emptive analgesia following epidural 0.5% bupivacaine. In thoracotomy. *Reg Anesth.* 1994; 19:72.

24. Seago JA, Weitz S, Walczak S. Factors influencing stay in the postanesthesia care unit: a prospective analysis. *J Clin Anesth*. 1998; 10:579–87. [PubMed: 9805699]
25. Ganter MT, Blumenthal S, Dübendorfer S, Brunnschweiler S, Hofer T, Klaghofer R, Zollinger A, Hofer CK. The length of stay in the post-anaesthesia care unit correlates with pain intensity, nausea and vomiting on arrival. *Perioper Med (Lond)*. 2014; 3:10. [PubMed: 25485103]
26. American Society of Anesthesiologists Task Force on Acute Pain Management. Practice guidelines for acute pain management in the perioperative setting: an updated report by the American Society of Anesthesiologists Task Force on Acute Pain Management. *Anesthesiology*. 2012; 116:248–73. [PubMed: 22227789]
27. Katz J, Cohen L, Schmid R, Chan VW, Wowk A. Postoperative morphine use and hyperalgesia are reduced by preoperative but not intraoperative epidural analgesia: implications for preemptive analgesia and the prevention of central sensitization. *Anesthesiology*. 2003; 98:1449–60. [PubMed: 12766657]
28. Sullivan MD, Bauer AM, Fulton-Kehoe D, Garg RK, Turner JA, Wickizer T, Franklin GM. Trends in Opioid Dosing Among Washington State Medicaid Patients Before and After Opioid Dosing Guideline Implementation. *J Pain*. 2016; S1526-5900:00499–5.
29. Dabu-Bondoc SM, Maslin B, Dai F, Cong X, Watrous G. Evaluation of postoperative pain in the postanesthesia care unit: a ten-year experience in a teaching hospital. *Proceedings of the American Society of Anesthesiologists 2015 Meeting*. Oct 24–28.2015

Figure 1.

Epidural Infusion Duration and PACU LOS. PACU length of stay (hours), presented on a logarithmic scale. Epidural usage (% of procedure duration) determined by the ratio of infusion duration to procedure duration. *PACU*= Post-anesthesia care unit

Figure 2.
Epidural Infusion Start Time vs. Procedure Start Time and PACU LOS. *PACU* = Post-anesthesia care unit

Table 1

Study Population Characteristics, By Infusion Group

Outcome Variable		Group 1 No Infusion (N=374)	Group 2 Yes Infusion (N=540)	p-value
		n (%)	n (%)	
Gender (female)		227 (61)	312 (58)	.378
Age (years)	mean +/- st. dev	55.4 +/- 15.3	56.6 +/- 14.7	.233
Weight (kg)	mean +/- st. dev	82.4 +/- 24.6	80.9 +/- 22.7	.337
Procedure Duration (min)	mean +/- st. dev	218 +/- 100	252 +/- 114	<.001
Pain risk factors				
Chronic Opioid Use		37 (10)	39 (7)	.150
Complex Surgery		87 (23)	143 (26)	.270
Current Use of Sedatives		13 (3)	14 (3)	.438
History of Difficult Pain Control		5 (1)	10 (2)	.547
History of Substance Abuse		7 (2)	6 (1)	.340
Obstructive Sleep Apnea		25 (7)	37 (7)	.921
Number of pain risk factors	none	244 (65)	341 (63)	.731
	1	93 (25)	157 (29)	
	2	30 (8)	35 (6)	
	3+	7 (2)	7 (1)	
Procedure type	Thoracic	59 (16)	61 (11)	.004
	Abdominal	288 (77)	460 (85)	
	Extremity	27 (7)	19 (4)	
ASA class	I	6 (2)	8 (1)	.464
	II	121 (32)	178 (33)	
	III	218 (58)	329 (61)	
	IV	28 (8)	25 (5)	

ASA = American Society of Anesthesiologists, st. dev = standard deviation

Table 2

Intraoperative Opioid Use, By Infusion Group

Outcome Variable		Group 1 No Infusion (N=374)	Group 2 Yes Infusion (N=540)	p-value
<u>Fentanyl</u>	n (%)	301 (80)	467 (86)	.015
	mean dose (mcg); (95% CI) *	181 (26, 336)	189 (65, 314)	.424
<u>Hydromorphone</u>	n (%)	188 (50)	287 (53)	.391
	mean dose (mg); (95% CI) *	1.7 (0, 4)	1.5 (0, 3)	.048
<u>Any Intraoperative IV opioid use (OME)</u>	n (%)	341 (91)	513 (95)	.022
	mean dose (mg); (95% CI) *	68 (10, 125)	69 (26, 112)	.734

* =Data representative of patients who received one or more doses post-operative intravenous opioid.

IV = intravenous, *mcg* = micrograms, *mg* = milligrams, *OME* = oral morphine equivalents

Table 3

a–c: PACU LOS and IV Opioid Use, By Infusion Group

Outcome Variable		Group 1 No Infusion (N=374)	Group 2 Yes Infusion (N=540)	p-value
A. PACU LOS *	mean (min); (95% CI)	161 (151, 172)	141 (134, 149)	.002
	relative diff. (95% CI)	--	0.88 (0.81, 0.96)	.005 **
B. PACU IV opioid use (any dose)	n (%)	181 (48)	186 (34)	<.001
	odds ratio; 95% CI	--	0.60 (0.45–0.80)	<.001 **
Fentanyl	n (%)	84 (22)	85 (16)	.010
Hydromorphone or Morphine	n (%)	132 (55)	138 (26)	.002
C. Cumulative PACU IV opioid use (OME)	mean dose (mg); (95% CI) **	53 (42, 67)	71 (57, 90)	.074
	relative diff. (95% CI) ***	--	1.36 (0.98–1.89)	.064 **

* =Data available in 538 procedures (Group 1: n=230; Group 2: n=308);

** =Analyses adjusted for patient age, gender, weight, any pain risk factors (yes/no), intraoperative administration use (yes/no), procedure type, ASA code, and procedure duration. PACU LOS analysis additionally corrected for the use of any anti-emetics.

*** =Data representative of patients who received one or more doses post-operative intravenous opioid.

CI = confidence interval, IV = intravenous, LOS = length of stay, OME = oral morphine equivalents, min = minutes, mg = milligrams, PACU = post-anesthesia care unit

Table 4

PACU Patient-Reported Pain Scores (NRS), By Infusion Group

	Group 1 No Infusion (N=374)	Group 2 Yes Infusion (N=540)	Group Difference	p-value*
<u>FIRST</u>	4.6 +/- 3.6	4.1 +/- 3.5	0.4 (-0.1 - 0.9)	.111
<u>MAX</u>	6.0 +/- 3.1	5.3 +/- 3.2	0.5 (0.0 - 0.9)	.030
<u>LAST</u>	2.8 +/- 2.4	2.8 +/- 2.5	-0.1 (-0.5 - 0.2)	.438

*=Analyses adjusted for patient age, gender, weight, any pain risk factors (yes/no), procedure type, ASA code, and procedure duration.

PACU = Post-anesthesia care unit, NRS = Numeric Rating Scale