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ORIGINAL PAPER

Comparison of analgaesia with lumbar epidurals and lumbar plexus nerve blocks in patients receiving multimodal analgaesics following primary total hip arthroplasty: a retrospective analysis

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Abstract
Purpose Significant post-operative pain occurs after hip arthroplasty. In a prior study, lumbar plexus nerve blocks provided comparable analgaesia to lumbar epidurals; however, multimodal analgaesics were not used consistently.
Methods This study assessed a randomly selected cohort of 48 patients undergoing primary hip arthroplasty who received a regional anaesthesia technique for post-operative pain. Twenty-four patients with lumbar epidurals and 24 with single-injection lumbar plexus nerve blocks were reviewed using electronic medical records. Post-operative opiate consumption was the primary endpoint. Secondary endpoints were participation in physical therapy, side effects, and time to discharge. Descriptive statistics were calculated to describe patients in the different groups. Opiate consumption was compared using linear mixed models. Multivariable models were examined for both primary and secondary endpoints.
Results In comparison with patients receiving lumbar epidural catheters, patients with lumbar plexus blocks consumed less opiates post-operatively at 24–36 and 36–48 hours ($P = 0.037$ and 0.002, respectively); it did not differ at zero to 12 hours or 12–24 hours post-operatively. Patients with lumbar plexus blocks had earlier times to first ambulation (28.5 ± 3.29 vs 21.9 ± 1.76 h; $P = 0.043$). However, differences by block type were not observed for ambulation distance, level of assistance to ambulate or time of discharge orders.
Conclusions Following primary total hip arthroplasty, lumbar plexus nerve blocks provide effective post-operative analgaesia with decreased opiate consumption compared with lumbar epidural catheters. Lumbar plexus blocks also promote earlier post-operative ambulation and are compatible with post-operative prophylactic anticoagulants.

Keywords Nerve block · Anesthaesia · Epidural · Arthroplasty · Hip replacement · Pain · Post-operative · Analgaesia

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Introduction

The demand for total hip arthroplasty (THA) continues to increase, with the obvious goals of improving physical function [1]. However, THA is associated with post-operative pain, which remains a serious concern for patients [2, 3]. Further, post-operative ambulation may be delayed by poorly treated post-operative pain, increasing the risk of pulmonary complications and venous thrombosis [4, 5].

In the face of a growing opiate epidemic, multimodal approaches that use both nonopiate analgaesics and regional anesthetic techniques are being increasingly examined. Nonopiate analgaesics administered orally have been associated with faster rehabilitation following joint arthroplasty [6,

7]. Similarly, regional anesthetic techniques have been associated with both decreased opiate consumption and pain scores compared with systemic analgaesia alone [7–11]. However, regional techniques for THA are seldom compared. Although superior to intravenous (IV) medication alone for analgaesia after THA [11], continuous epidural analgaesia (CEA) has some well-known side effects, including urinary retention, hypotension, and bilateral lower-extremity weakness. Additionally, as arthroplasty patients are at increased risk of venous thromboembolism (VTE) formation, anticoagulants or antiplatelet therapy are often started that are not compatible with an indwelling epidural catheter [12]. In contrast, lumbar plexus nerve blocks also reduce post-operative pain after THA while avoiding some side effects common to neuraxial analgaesia [10, 13, 14]. A recent, retrospective study noted lumbar plexus blocks provide post-operative analgaesia comparable with CEA [15]. However, a limitation to this study was the lack of standardisation for oral administration of nonopiate analgaesics between block groups.

This study compared a retrospective cohort of patients who received a multimodal approach for post-operative analgaesia after THA that included nonopiate analgaesics orally and either a continuous lumbar epidural catheter or single injection lumbar plexus nerve block. We hypothesised that lumbar plexus peripheral nerve blocks would provide comparable post-operative analgaesia to CEA. The primary outcome was post-operative opiate consumption measured in morphine equivalents intravenously (IV) . Secondary outcomes included time to first ambulation, ambulation distance, assistance level required to ambulate, occurrence of opiate-related side effects, and time to discharge.

Materials and methods

Following institutional IRB approval, a retrospective cohort study was carried out using electronic medical records for patients who had undergone primary THA by the direct lateral approach at a single academic institution between 23 July 2014 and 25 June 2015. Written informed consent was waived by the IRB. The trial was registered at clinicaltrials.gov (NCT02493621).

Power

Based on a prior study [15], 48-h morphine equivalent consumption IV in the lumbar plexus group was anticipated to be 64 mg ± 7 mg. A sample size of 24 per group was needed to provide >90% power to detect a consumption difference of 7.0 mg assuming a standard deviation (SD) in both groups of 7 mg ($\alpha = 0.05$) using a two-sided Mann–Whitney test.

Study design

Current Procedural Terminology (CPT) code 27130 was used to identify potential patients, and electronic medical records were examined to distinguish patients meeting inclusion/exclusion criteria. A flow chart detailing patient selection is shown in Fig. 1. Inclusion criteria consisted of primary elective THA surgery with either (1) a lumbar epidural ($n = 51$) or (2) a lumbar plexus peripheral nerve block ($n = 312$) for post-operative analgaesia. Exclusion criteria were THA revision, traumatic fractures, nonelective surgery, general anaesthesia, and post-operative intensive care unit (ICU) admission. Additional analgaesic exclusion criteria were not receiving a regional block for post-operative analgaesia, nonfunctional regional analgaesia block, and not receiving nonopiate analgaesics orally; nonopiate analgaesics were administered orally to all patients pre- and post-operatively as part of a joint arthroplasty pathway and consisted of scheduled gabapentin, celecoxib, and acetaminophen. Of the charts reviewed, 31 lumbar epidural and 153 lumbar plexus patients met inclusion criteria and were assigned a chronological number based on the date of their operation (Epidural 1–31; Lumbar plexus 1–153). These numbered lists were then randomised using Microsoft Excel; data were collected on the first 24 randomised patients for each block type.

Data collection

Patient charts were examined and data gathered by two separate investigators to ensure consistent data collection. Cumulative post-operative opiate consumption 48 hours after surgery was the primary outcome examined. All opiates were converted to morphine IV equivalents (mg) for ease of comparison: 1 mg morphine IV= fentanyl IV (0.01 mg), hydromorphone IV (0.15 mg), oxycodone orally (2 mg), hydrocodone orally (3 mg), and meperidine IV (7.5 mg). The anaesthesia end time was designated as time zero. Opiate consumption was examined in 12 hour intervals (0–12, 12–24, 24–36, 26–48 h) until 48 hours after surgery or hospital discharge, whichever came first. All medications administered in pre-operative holding or the operating room (OR) were designated as OR opiates. Opiates administered after the anaesthesia end time in the postanaesthesia care unit (PACU) were included as opioid consumption for the first post-operative time interval (0–12 h).

We evaluated multiple secondary outcomes of demographic data, total operating room time, time to first ambulation, distance ambulated, and assistance level required for ambulation, with the latter being assigned a number based on the Functional Independence Measure (FIM) scale [16]. Additional secondary outcomes were post-operative discharge time, and common side effects of dizziness (documented by physical therapy or nursing), pruritus (administration of

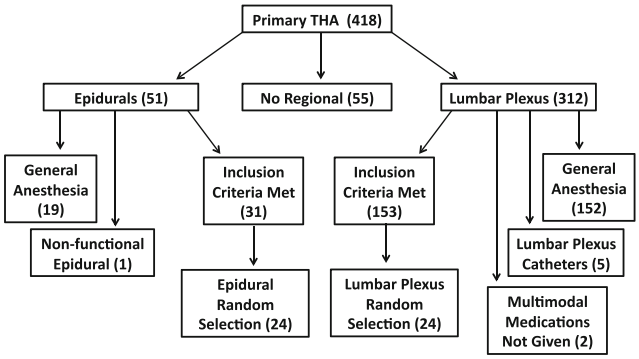

Fig. 1 Study overview

diphenhydramine or hydroxyzine), nausea (administration of ondansetron or promethazine), or hypotension (documented blood pressure ≤20% below baseline).

Statistics

The primary outcome of interest was total opiate consumption over time examined by the type of regional technique used for post-operative analgaesia. Descriptive statistics were used to characterise patients by block type. Morphine consumption was compared using linear mixed models, including a random subject effect to account for repeated measures of opioid consumption over time. To determine whether any covariates impacted morphine consumption over time, additional models were examined, with time as a second covariate and then with an interaction between the covariate and time. In a multivariable model, main effects for analgaesic block type and time and interaction between block type and time were considered. Different covariance structures were examined, including first-order autoregressive, heterogeneous first-order auto regressive, compound symmetry, and unstructured. The most appropriate structure was chosen by comparing Akaike information criterion. Covariates with a univariate association ($P < 0.2$) with morphine consumption were also considered in a multivariable model. The final model was selected using backwards selection, retaining all covariates with significance of ≤0.05. Model assumptions were checked graphically and variable transformations were considered when appropriate. Contrasts were used to examine differences between block types at each time point. The Tukey–Kramer adjustment was used to control for multiple comparisons.

Secondary outcomes were first ambulation time, ambulation distance, assistance required with ambulation, occurrence of side effects and time to discharge orders. Linear mixed models were employed to examine associations between different variables and distance ambulated. To account for repeated measures over time, generalised linear mixed models with a cumulative logit link were used to consider the association between different variables and level of assistance required with ambulation. Associations between categorical variables and time to first ambulation or to discharge orders were evaluated using a two-sample independent *t* test or the Wilcoxon rank-sum test, where appropriate. Associations with continuous variables were evaluated using Pearson's correlation or Spearman's rank correlation, where appropriate. Associations between categorical variables and occurrence of side effects were evaluated using chi-square tests and with logistic regression for continuous variables. Multivariable regression models for all secondary outcomes were also developed. All variables with univariate associations of $P < 0.2$ with the dependent variable were considered in the multivariable modes. Final models were selected using backwards selection, retaining all covariates with significance of $P < 0.05$. Model assumptions were checked graphically, and variable transformations were considered when appropriate. All analyses were done using SAS v 9.3 (SAS Institute, Cary, NC, USA).

Results

Data collection was successful for 24 patients in each group. All regional blocks were placed in the pre-operative holding area on the day of surgery in preparation for post-operative analgaesia. Lumbar epidurals were initiated and given a bolus intra-operatively before an infusion was started (ropivacaine 0.2%, 8 ml/h). Epidural rates were titrated in the PACU for patient comfort prior to discharge to the floor. All epidurals were removed the morning of post-operative day (POD) 1 to allow administration of anticoagulants for VTE prevention. Lumbar plexus blocks were performed as a single injection (20 ml, 0.5% ropivacaine). Demographic data did not differ between groups. Patients with a lumbar plexus block had 23.8% longer OR times than patients with epidurals (Table 1; $P = 0.005$).

Primary outcome

Cumulative 48-h postoperative opiate consumption did not differ by block type, gender, race, total OR time, or time; intra-operative opiate consumption was greater in patients with lumbar plexus blocks ($P = 0.008$; Table 1). Increased post-operative opiate consumption was associated with increased intra-operative opiate consumption ($P = 0.049$). Post-operative opiate consumption was also significantly associated with age. Specifically, a five year increase in age was associated with a 10.9% decrease in opiate consumption ($P = 0.012$).

Opiate consumption over time was log transformed to meet modeling assumptions in all multivariable models. Variables considered in the final model were block type, operative opiate consumption, age, time and interaction between block type and time. Controlling for other factors, a 10% increase in the

Table 1 Patient characteristics and analgaesic consumption

	Epidural (n = 24)	Lumbar plexus (n = 24)	P value
Age (years)	61.2 (2.55)	62.1 (2.32)	0.795
Gender (male)	12 (50.0)	11 (47.8)	0.773
Race (white)	23 (95.8)	18 (75.0)	0.097
OR time (h)	2.54 (0.14)	3.15 (0.15)	**0.005**
Total morphine equivalents (mg)	53.9 (6.31)	48.6 (5.21)	0.506
Intraoperative (mg)	7.90 (1.33)	12.2 (1.24)	**0.008**
Postoperative (mg)	46.0 (5.86)	36.4 (4.91)	0.190

Continuous variables: mean (standard error); categorical variables n (%)

ME morphine equivalents

Significant P values (less than or equal to 0.05) were bolded

amount of opiates given in the OR was associated with a 7.2% increase post-operatively [P = 0.018, 95% confidence interval (CI) = 1.47–12.8%). Additionally, opiate consumption differed by block types at 24–36 and 36–48 hours (Fig. 2). Specifically, relative to patients with lumbar plexus blocks and controlling for amount of opiate received in the OR, patients with epidurals consumed on average 62% more morphine equivalents between 24 and 36 hours (P = 0.037, 95% CI = 4.4–119%) and 69% more opiates between 36 and 48 hours (P = 0.020, 95% CI = 11.4–126%).

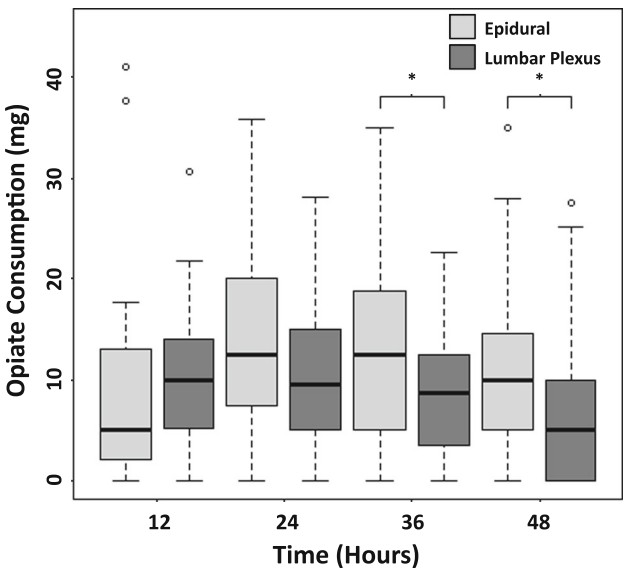

Fig. 2 Opioid consumption was decreased at 24–36 and 36–48 hours post-operatively in patients with lumbar plexus blocks compared with lumbar epidurals. The *dark line* represents median opioid consumption in morphine IV equivalents (mg). *Boxes* represent the 25th–75th percentile for each group. *Whiskers* extend to ×1.5 the interquartile range from the 25th–75th percentile. *P < 0.05 (after adjusting for multiple comparisons)

Secondary outcomes

We examined associations between block type and secondary outcomes of time to discharge orders, time to first ambulation, distance ambulated, level of assistance required ambulation and occurrence of side effects. Any variables with P < 0.02 in univariate analyses were considered in the multivariable models.

Side effects

Side effects were not associated with block type. Increased age was associated with dizziness (P = 0.0080) and post-operative hypotension (P = 0.012). Given the low incidence of side effects, multivariable models were not considered.

Time to first ambulation

Time to first ambulation was associated with both block type and the occurrence of dizziness within the first 24 hours post-operatively (P = 0.043 and 0.014, respectively). These finding were consistent in a multivariable model. Patients with epidurals ambulated 7.4 hours later when controlling for dizziness (P = 0.028). Patients with dizziness in the first 24-hours post-operatively also ambulated 20.9 hours later than patients without dizziness controlling for block type (P < 0.001).

Distance ambulated

Ambulation distances were not associated with block type but were increased with male gender (P < 0.001), decreased age (P = 0.020) and increased post-operative time. In the multivariable model, gender, age, block type and post-operative time of physical therapy sessions were considered (Table 2). Later physical therapy times were associated with an increase in the mean distance ambulated relative to earlier times, controlling for other factors (P < 0.001). While all patients ambulated further at later time points, women did not show as rapid an increase as men over time (P = 0.024.) There was also a trend towards patients with lumbar plexus blocks ambulating farther than those with epidurals after controlling for other factors; however, this association did not reach statistical significance (P = 0.081; Fig. 3).

Level of assistance to ambulate

Level of assistance for ambulation was examined using the FIM scale. Increased assistance was associated with increased age (P < 0.001), female gender (P = 0.004) and earlier POD therapy sessions (P < 0.001 for both POD 0 vs. 1 and POD 0 vs. 2; P = 0.004 for POD 1 vs 2). Odds ratios (OR) are presented for the multivariable model in Table 3. In the final model, level of assistance needed to ambulate remained

Table 2 Estimated mean difference in distance ambulated by block type and gender at 24, 36, 48, 60 and 72 h based on contrasts from the multivariable regression model

Comparison	Mean difference (feet)	95% CI	*P* value
Lumbar plexus vs. epidural	31.9	−4.06, 67.9	0.081
Males vs. females at 24 h	63.9	−8.75, 136.5	0.084
Males vs. females at 36 h	81.1	−0.04, 162.2	**0.050**
Males vs. females at 48 h	98.3	8.11, 188.5	**0.033**
Males vs. females at 60 h	115.5	15.9, 215.2	**0.024**
Males vs. females at 72 h	132.7	23.3, 242.2	**0.018**

Significant P values (less than or equal to 0.05) were bolded

associated with POD and age. Patients also had elevated odds of needing increased assistance on POD 0 vs 1, POD 0 vs 2 and POD 1 vs 2 controlling for block type and age ($P < 0.001$). A 10-year increase in age was associated with threefold increase in the odds of needing greater assistance controlling for other factors ($P < 0.001$). Block type was not associated with assistance level after controlling for other variables ($P = 0.605$).

Time to discharge orders

Median discharge times were increased by both increased age ($P = 0.013$) and post-operative dizziness ($P = 0.038$). The impact of gender, morphine consumption and dizziness were included in the final multivariable model. Controlling for other factors, dizziness increased discharge times by 27.6% ($P = 0.041$), female gender by 21% ($P = 0.029$) and a 10 mg increase in total morphine-equivalent consumption by 3.8% ($P = 0.047$).

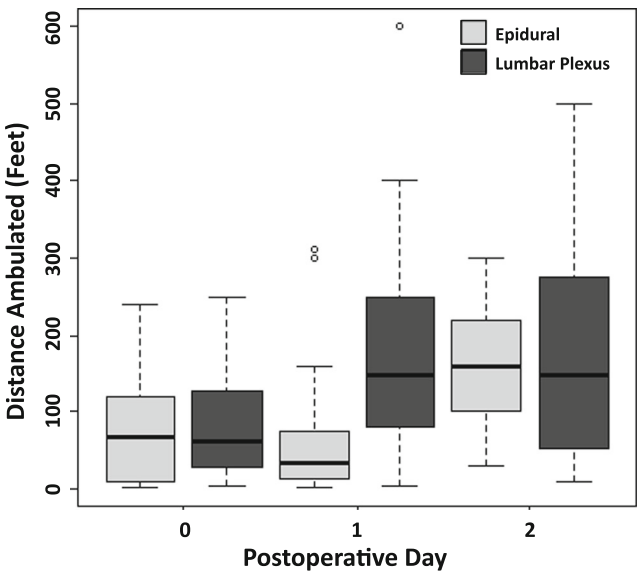

Fig. 3 Distance ambulated by patients on each post-operative day (POD). Ambulation distance was not impacted by block type. The *dark line* represents the median distance ambulated (feet). *Boxes* represent the 25th–75th percentile for each group. *Whiskers* extend to ×1.5 the interquartile range from the 25th–75th percentile

Discussion

This retrospective study compared cumulative opioid consumption in patients undergoing elective primary THA who received either lumbar plexus block or lumbar epidural infusion in addition to a consistent multimodal analgaesia regimen orally. Total opiate consumption 48 hours post-operatively did not differ between groups. However, in a multivariable model, lumbar plexus blocks were associated with decreased opiate consumption at 24–36 and 36–48 hours post-operatively. A similarly designed retrospective publication comparing lumbar plexus and lumbar epidural infusions after primary THA also found lumbar plexus nerve blocks to decrease opiate consumption 12- to 48 hours post-operatively [15]. However, that study did not standardise the oral administration of nonopiate analgaesics. As nonopiate analgaesics were given to all patients in our cohort, the increased opiate consumption noted with the epidural group at 24–48 hours is likely due to epidural removal on the morning of POD 1 and return of sensation. These data support prior findings that, compared with lumbar epidural infusions, lumbar plexus nerve blocks offer effective post-operative pain management following THA.

Notably, patients with lumbar plexus blocks received more opiates in the OR. As many patients undergoing lower-extremity arthroplasty seek surgery due to long-term arthritic pain after trying analgaesics orally, this may simply represent increased chronic opiate requirements; however, all our elective patient are directed to hold all analgaesics—including

Table 3 Odds ratios (OR) and 95% confidence intervals (CI) for level of assistance by different variables in the cumulative logistic regression model

Comparison	OR	95% CI	*P*
Lumbar plexus vs. epidural	1.39	0.40, 4.82	0.605
POD 0 vs. POD 1	6.24	2.51, 15.5	**<0.001**
POD 0 vs. POD 2	28.9	8.19, 102	**<0.001**
POD 1 vs. POD 2	4.63	4.63, 12.8	**0.004**
10-year increase in age	2.97	1.70, 5.21	**<0.001**

ORs represent odds of having a lower FIM scale number [16](i.e. needing more assistance) for the relationship described

Significant P values (less than or equal to 0.05) were bolded

opiates—for two weeks prior to surgery. As post-operative opiate consumption was also associated with intra-operative consumption, this may simply reflect opiate sensitisation from chronic use [17]. Additionally, patients with lumbar plexus blocks had increased operative durations (23.8%) than those with epidurals, which may indicate that lumbar plexus block patients had more extensive operations that were potentially more painful. Further, as all patients received a neuraxial anesthetic, intra-operative opiate consumption may have increased with increased surgical duration as spinal anaesthesia resolved. Notably, while increased postoperative opiate consumption was associated with increased intra-operative opiate consumption, patients with lumbar plexus blocks still had reduced opiate consumption 24 hours post-operatively.

Several secondary outcomes examined functional recovery, as early physical therapy after THA has been linked with improved rehabilitative success. However, block type in our study did not significantly impact distance ambulated or amount of assistance required during physical therapy. This result may be influenced by our comparison of physical therapy session number regardless of post-operative time. Distance ambulated and level of assistance to ambulate was examined in every patient who could and would ambulate. Patients who did not or could not ambulate were not included. Since more lumbar plexus patients were ambulating relative to epidural patients, we thought giving all epidural patients "0" scores would inflate data. Concomitantly, improved ambulation distance and decreased assistance were both associated with increased recovery time. Patients who received lumbar epidural analgaesia ambulated an average of 7.4 hours later than those receiving a lumbar plexus block in a multivariable analysis. These findings are consistent with past publications noting that lumbar plexus blocks promote ambulation following THA [14, 15]. Additionally, past comparisons of lumbar plexus blocks to lumbar epidurals have noted improved ambulation distances with decreased assistance.

Distance ambulated was also delayed 20.9 hours in patients with dizziness controlling for block type. The presence of dizziness was associated with age and not with block type. Conversely, in a population at high risk for dizziness following cochlear implant surgery, dizziness was not associated with age [18]. Notably, our multimodal regimen includes gabapentin, which has been associated with dizziness in past studies [19]. However, a recent meta-analysis that examined gabapentinoids in patients undergoing THA found no difference in dizziness between patients who did and did not receive these medications [20].

Limitations

Certain limitations to this study are inherent to its retrospective nature. Multiple study personnel collected data on each patient to limit data collection error. The aim was to compare two different block types with similar intra-operative and post-operative care and all patients received a standardised perioperative multimodal analgaesic regimen; however, individual medications could be held for patient allergies, intolerances or comorbidities that contradicted administration.

Conclusions

Lumbar plexus blocks provide effective post-operative analgaesia for THA patients, with decreased opiate consumption at 24–48 hours compared with lumbar epidural analgaesia when all patients received oral, nonopiate analgaesics. Single-injection lumbar plexus block also expedite initiation of early postoperative physical rehabilitation without impeding post-operative VTE prophylaxis.

Compliance with ethical standards

Disclosure and conflict of interest On behalf of all authors, the corresponding author states that there are not any conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. For this type of study, formal consent is not required.

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