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Transmuscular Quadratus Lumborum and Lateral Femoral Cutaneous Nerve Block in Total Hip Arthroplasty

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Abstract

Objectives: Adequate pain control after total hip arthroplasty is essential for patient satisfaction and surgical outcome.

Methods: A retrospective study with before and after design was performed in 210 elective total hip arthroplasty patients. Control group (N=132) received spinal anesthesia with periarticular injection (PAI), and Treatment group (N=78) received transmuscular quadratus lumborum block and lateral femoral cutaneous nerve block in addition to spinal anesthesia and PAI. Primary outcome was VAS pain score on postoperative day (POD) 1, secondary outcomes included VAS and opioid consumption on each POD, hospitalization cost, length of stay, and discharge acuity.

Results: The mean VAS and opioid consumption (MME) were significantly lower in the treatment group than that in the control group on POD 1, with VAS difference = −1.10, 95% CI, −1.64 to −0.55, False discover rate corrected $p<0.001$, and MME difference =−26.19, 95 CI%, −39.16 to −13.23, $p<0.001$. A significant difference was also found for both VAS ($p = 0.007$) and opioid consumption ($p = 0.018$) on POD 2 and for opioid consumption on POD 3 ($p = 0.008$). Length of stay (days) in control group vs treatment group was 2.50 ± 1.38 vs 1.36 ± 0.95 ($p=0.002$), and the total cost of hospitalization was over 20% higher in the control group than that in treatment group ($p=0.002$).

Discussion: The addition of transmuscular quadratus lumborum and lateral femoral cutaneous nerve block in total hip arthroplasty provides improved analgesia indicated by lower pain scores and opioid reduction, and accelerated recovery with shorter hospitalization and decreased hospitalization cost.

Keywords

Glucocorticoid; lateral femoral cutaneous nerve block; quadratus lumborum block; total hip arthroplasty

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1. Introduction

Total hip arthroplasty (THA) is one of the most common procedures performed in the United States, with case volume expected to continue to increase in this aging population.[1] Inadequate pain control not only affects patient satisfaction but also negatively impacts surgical outcomes. This in turn can be associated with increased hospital length of stay, cost, and complications such as pneumonia, deep venous thrombus, and pulmonary embolism.

Traditionally, because THA is not considered incredibly painful, the peri-articular injection (PAI) with local anesthetics such as plain bupivacaine or ropivacaine, or in conjunction with adjuvants such as epinephrine, ketorolac, glucocorticoids, and/or morphine is the most common type of opioid-sparing analgesic technique used perioperatively. Historically, common peripheral nerve blocks utilized in THA include femoral nerve block, fascia iliaca block, and lumbar plexus block, in the format of single injection or continuous catheter placement. There are however inherent issues with these earlier peripheral nerve block techniques such as motor weakness and delay in initiation of physical therapy, with some experts advocating moving away from nerve block and transitioning towards PAI.[2, 3] Debate surrounds the issue of whether peripheral nerve blockade, PAI, or both should be employed within a contemporary, comprehensive multimodal analgesia pathway for total hip arthroplasty.[2, 3] Various protocols have been utilized, however no consensus has been reached for an optimal analgesia plan.[2, 3] In recent years, studies have shown improved analgesia and minimal motor weakness when comparing emerging/newer peripheral nerve block techniques such as the ultrasound guided transmuscular quadratus lumborum (QL3) block (T7-L1) and lateral femoral cutaneous nerve (LFCN) block (L2-3), to traditional peripheral nerve block techniques.[14, 5] One shortcoming of local anesthetic nerve blocks is the duration of action, with the typical block providing a few hours of analgesia.[6] Several adjuvants have been successfully used to prolong the duration of analgesia including steroids such as dexamethasone sodium phosphate (DEX) and methylprednisolone acetate (MPA, Depo-Medrol). Studies have shown that blocks with perineural dexamethasone have a longer duration of action than intravenous dexamethasone.[6]

In this institution, we have recently implemented a THA nerve block protocol with the newer motor-sparing blocks (QL3 and LFCN) in addition to the routine PAI. In this retrospective study with before and after design, we investigate whether transmuscular quadratus lumborum block/lateral femoral cutaneous nerve block in combination with PAI vs PAI alone has a significant effect on postoperative pain control, postoperative opioid consumption, length of hospitalization, and hospitalization cost.

2. Materials and Methods

2.1 Study Design

This study adhered to the STROBE guidelines.[7] With institutional review board approval, data was extracted from the electronic medical record for 228 patients who received elective total hip replacement surgery under spinal anesthesia between July 2017 and July 2019 (Figure 1). Patients who received multiple hip replacements in this time frame were counted as different patients. During this period, a new pain management regimen was implemented

with the addition of preoperative peripheral nerve block (PNB) including QL3/LFCN block. There were no other additional changes on patient management. Patients were grouped based on whether they received the QL3/LFCN block. The control group (Spinal with PAI) received the standard of care in this institute including intraoperative spinal anesthesia and PAI by the surgeon, and the treatment group (Spinal with PAI/PNB) received preoperative QL3/LFCN block in addition to intraoperative spinal anesthesia and PAI. 16 patients were excluded who received general anesthesia instead of spinal anesthesia, and 2 patients did not have accurate postoperative data recorded. A total of 210 records were included in the final analysis.

2.2 Anesthesia procedures

All blocks were performed in the preoperative area with ultrasound guidance by a regional anesthesia trained anesthesiologist. LFCN block was performed supine while transmuscular QL3 block was performed in the lateral decubitus position using a curvilinear transducer. Standard American Society of Anesthesiologists (ASA) monitors were used and minor sedation using intravenous midazolam and/or fentanyl was administered as needed. Blocks were performed with 40 mL 0.2% ropivacaine, 5 mg of DEX and 40 mg MPA in the QL3 block, and 20mL 0.2% ropivacaine, 5 mg of DEX and 40 mg MPA in the LFCN block.[8] Patients were then taken to the operating room where all patients received spinal anesthesia with 0.5% plain bupivacaine. Periarticular injection was performed at the end of the surgery with local anesthetic and adjuvants at the surgeon's discretion. Postoperatively all patients received around the clock acetaminophen (975 mg Q6h) and celecoxib (100 mg Bid), with oral opioids, ketorolac, or intravenous opioids for breakthrough pain.

2.3 Outcomes

Data on anesthesia type, body mass index (BMI), sex, age, length of surgery, surgical approach, ASA status, postoperative opioid consumption, postoperative visual analog scale (VAS) pain scores, hospital length of stay and cost, and disposition were collected for all patients. The primary outcome was VAS pain score at POD 1, while secondary outcomes included opioid consumption and pain scores over time (POD 2 and POD 3), hospital length of stay, hospitalization cost, and disposition after hospitalization.

2.4 Statistical analysis

Data were summarized as number of observations (%) for categorical variables, mean values and standard deviation (SD) for continuous variables, both overall and across the treatment groups. For the univariate analyses, categorical variables between two groups were compared using the Fisher's exact test if the expected number of events are less than five; otherwise a Chi-Square test was used. Continuous variables were analyzed using the two-sample Welch t-test with unequal variances. No imputation was performed for missing patient characteristics and all the summary statistics and univariate analyses were conducted on complete cases.

Linear Mixed Model Repeated measures (MMRM) analysis was utilized to evaluate change in the pain score (opioid consumption outcomes analyzed in separate models), in which baseline (preoperative) value, time (e.g., day 1, 2, 3), group (treatment vs. control), and time

by group interaction were adjusted as covariates, with an unstructured variance-covariance matrix specified to account for within-subject correlation of repeatedly measured values during postoperative time periods. This method assumes that outcomes are missing values at random, relative to other variables we collected. In contrast to complete case analysis, patients were kept in the MMRM analysis as long as they had any outcome value collected at any postoperative day and there was no missing data in preoperative value. As there were no significant imbalance in patient characteristics between two groups suggested by univariate analyses ($p > 0.05$), no other covariates were included in the MMRM analysis. To quantitate the sizes of estimated effects, least square means and 95% confidence intervals (CI) were reported at each time point.

All statistical tests were performed using the statistical software SAS version 9.4 (Cary, NC). To correct for multiple testing in the evaluation of primary outcome and secondary outcomes, p-values were corrected for 9 comparisons using the false discovery rate (FDR)-controlling Benjamini-Hochberg procedure. [9] A p-value of less than 0.05 after correction was considered to be statistically significant.

3. Results

The patient demographic data showed no statistically significant differences in sex, age, BMI, and ASA physical status between the two groups (Table 1). The difference in surgical approach was not statistically significant ($p = 0.12$). An anterior approach was taken in 115 (87%) and 75 (96%) patients in the control and treatment groups respectively. A lateral approach was taken in 8 (6%) and 2 (3%) patients in the control and treatment groups respectively. A posterior approach was used in 9 (7%) and 1 (1%) patients in the control and treatment groups respectively. The difference in preoperative opioid consumption was not statistically significant between the two groups ($p = 0.38$), nor was there a statistically significant difference in the amounts of prescribed opioids at discharge between the two groups ($p=0.13$).

Our regression analysis (Table 2, Figure 2) showed that the average pain score on day 1 after the surgery was statistically significant (difference = −1.10, 95% CI: −1.64 to −0.55, FDR corrected $p < 0.001$) between two groups, with the treatment group having a lower average pain score of 3.74 (95% CI: 3.32 to 4.17) and the control group having a higher average pain score of 4.84 (95% CI: 4.50 to 5.18). There was also a statistically significant difference in average pain scores on day 2, while the average pain score was statistically lower in the treatment group (corrected $p = 0.007$). There was no statistically significant difference in pain score between the two groups on day 3 (corrected $p = 0.145$).

As shown in Table 2 and Figure 2, in the first day after surgery, patients in the control group had an average opioid consumption (MME) of 75.52 (95% CI: 67.65 to 83.39), while the treatment group had a lower average opioid consumption of 49.33 (95% CI: 39.03 to 59.64), and the difference is statistically significant (difference = −26.19, 95% CI: −39.16 to −13.23, corrected $p < 0.001$). The same patterns of statistically significant difference between control and treatment groups are also found at POD 2 (corrected $p = 0.018$), and POD 3 (corrected $p = 0.008$) respectively.

Discharge status included home or self-care, home-health care site, or skilled nursing facility (Table 2). 23 (17%) patients were discharged to home or self-care in the control group and 30 (38%) patients in the PNB treatment group. 79 (60%) patients in the control group were discharged to a home-health care site and 38 (49%) patients in the PNB treatment group. 30 (23%) patients were discharged to a skilled nursing facility in the control group and 10 (13%) from the PNB treatment group.

There was a statistically significant difference in the length of hospital stay between the two groups (corrected $p = 0.002$); the control group had an average length of hospital stay of 2.50 ± 1.38 days, while the treatment group's average was 1.36 ± 0.95 days. The difference in hospital costs between the spinal and PNB treatment groups was statistically significant, with the control group on average costing 20.6% more than that of the PNB treatment group (corrected $p = 0.002$, absolute value not shown).

4. Discussion

Effective pain control after total hip arthroplasty has paramount significance not only for patient comfort and satisfaction, but also because it is inherently linked to surgical outcome and perioperative mobility and mortality. To our knowledge, our study of 210 patients is the largest cohort of total hip arthroplasty patients treated with single injection QL3/LFCN blockade. With the addition of local anesthetic adjuvants DEX and MPA, patients in the treatment group demonstrated a significant reduction of opioid consumption (MME) ranging from 26.19 (35%) on POD 1, 14.64 (34%) on POD 2, to 16.26 (64%) on POD 3 respectively. Pain scores in our treatment cohort were statistically significantly lower for 48 hours postoperatively, most clinically significant on POD 1. The statistically significant pain score differences we observed represented a 16% to 23% decrease which is close to the 20% reduction found as clinically significant in most studies, but the absolute changes were with relatively small numbers ranging from 0.68 to 1.10.[10] Nonetheless, when considered together with the concomitant and consistent decrease of opioid consumption on each postoperative day, these changes in pain scores and opioid consumption are not only statistically relevant but also clinically meaningful in practice and clinical decision making. Physical therapists perceived better patient participation in routine twice daily physical therapy per institutional THA protocol due to improved pain control and there were no reports of ipsilateral lower extremity weakness.

Although these significant reductions of pain scores and in-hospital opioid consumption has not yet changed practitioner prescription behavior, as evidenced by our control and treatment groups receiving similar amounts of opioids at discharge, we have noticed some treatment group patients declined opioid prescription due to minimal pain at the time of discharge. This study also demonstrated a decrease in the length of stay with those in the treatment group staying over a day less on average compared to those in the control group. This resulted in an over 20% decrease in hospitalization costs. In addition, 83% of patients in the control group needed home health care or placement in skilled nursing facility on discharge while only 62% in the treatment group needed such high level of care. This newly implanted pain management regimen, with the introduction of novel combination of local anesthetic adjuvants in emerging motor-sparing PNBs, has allowed THA to transition from a mostly 2

nights-stay to a 23 hour-stay procedure, and even same day surgery in selected patients in our institute.

Chronic pain developing after total hip arthroplasty is a serious issue that can lead to life altering morbidity. In a study of over 1200 patients, 12.1% developed new postoperative chronic pain that limited daily activities.[11] Risk factors for developing postoperative chronic pain include preoperative pain, poorly controlled acute postoperative pain, and intraoperative nerve damage.[11] Because severe preoperative pain refractory to medical management is the indication for hip replacement, it is important to focus on reducing the amount of acute postoperative pain patients experience. Traditionally, pain after hip replacement has been managed with systemic opioids, nonsteroidal anti-inflammatories, and acetaminophen. However, some of these medications have significant adverse effects which can increase hospitalization times and reduce patient satisfaction scores. Neuraxial blocks have been used as an adjunct to decrease the amount of high potency opioids needed during and immediately after surgery but are potentially associated with motor weakness, seizures, hemodynamic instability, cardiac arrest, epidural/spinal hematoma, nausea, and urinary retention.[12] PAI of various anesthetics and analgesics have also been used with inconsistent effects.[3] PNBs have been used to combat postoperative pain. Historically, femoral nerve, fascia iliaca block and lumbar plexus blocks were used to achieve adequate analgesia however there is concern for quadriceps weakness and delayed physical therapy.[13, 14] Because of these concerns, alternative peripheral nerve block targets have been investigated including transmuscular QL3 and LFCN. Pain score and opioid reduction were reported in previous studies using transmuscular QL3 block for up to 24 hours and 48 hours respectively.[1, 15] In theory, QL3 may risk lumbar plexus spread, but quadriceps weakness has rarely been reported [16], therefore it has been considered a motor-sparing alterative to lumbar plexus block. The efficacy of LFCN alone in THA is not yet established.[17] We chose the above two PNBs in our pain regimen based on the dermatome distribution of each block, QL3 (T7-L1) and LFCN (L2-3) and the surgical techniques utilized by our surgeons.[8]

PNB catheters [18] and adjuvants that can prolong the pain relief provided by single shot local anesthetic peripheral nerve blocks have been used for better management of acute and sub-acute pain after THA. Liposomal bupivacaine has been used with some efficacy, however, there is a discrepancy between the manufacturer reported efficacy of 72 hours and what the current data support.[19, 20] DEX is a commonly adopted local anesthetic adjuvant to instantly augment block quality and prolong analgesic duration for about 6-8 hours.[21] The mechanism of action of perineural DEX in nerve blocks is not yet clearly revealed but literature has shown that perineural DEX has a vasoconstrictive effect and reduces regional blood flow without causing ischemia.[22] Other studies suggest DEX inhibits transmission in thin unmyelinated nociceptive C-fibers.[23] MPA is a liquid suspension, slow-release form of methylprednisolone with a good safety profile and similar mechanism to dexamethasone, it has been used in perineural injection in neuropathic, chronic pain, or as an adjuvant in neuraxial and peripheral nerve block to treat chronic pain.[24-27] MPA is routinely used for prolonged pain control for weeks or months but not commonly used for acute pain secondary to its variable onset of effect up to 24 hours.[27] Because of the varying onset and duration of action of DEX and MPA, their combination with local anesthetic may provide significantly longer effective analgesia throughout the immediate postoperative period

without gaps of pain relief, even though we understand the analgesic effects may partially stem from systemic absorption. Combining 2 glucocorticoids has been used for other indications, for example Celestone Soluspan (betamethasone sodium phosphate and betamethasone acetate) is used intramuscularly to treat multiple chronic conditions including severe allergies, tenosynovitis, peritendinitis, bursitis, rheumatoid arthritis, osteoarthritis, multiple sclerosis, dermatological diseases and rheumatic disorders.[28] At first, we chose the most commonly used hydrophilic glucocorticoids dexamethasone for peripheral nerve block and arguably the most commonly used lipophilic glucocorticoids for chronic pain procedures methylprednisolone acetate. Celestone Soluspan was trialed as the steroid of choice in the block, but the effects were not as good as the combination of DEX and MPA, likely due to the smaller molecule and particle size of betamethasone acetate, leading to faster absorption and shorter duration.[29] In this study, with the innovative utilization of DEX and MPA, we were able to achieve statistically significant and consistent opioid reduction on each postoperative day throughout the hospitalization for at least 72 hours.

We note there are several limitations in this study. First, retrospective studies are not appropriate to study analgesic interventions in general as they have inherent inadequacies in data collection, patients are not matched for comorbidity. There are social and human factors in a retrospective cohort study that can affect length of stay and discharge deposition. We did not have complete documentation of the frequency or severity of quadriceps weakness assessment, however, if there was any weakness, it was not severe enough to interfere with routine twice daily physical therapy. The cost of hospitalization can only be reported as percentage changes but not absolute values, which could limit its generalization. Although the control and treatment cohorts are next to each other in time frame with the before and after design, and no additional major changes took place around that time frame, small changes in care management, surgical technique and patient trends may have occurred and therefore affected quality metrics. Second, although the performance of QL3 and LFCN blocks were standardized among experienced anesthesiologists, dermatomal level assessment after peripheral nerve block placement was not performed. Instead, sonographic local anesthetic spread was used as an indicator for satisfactory block. In addition, PAI technique and medications used were at each surgeon’s discretion. A majority of the surgeries were performed using the anterior approach to the hip, therefore the effects of these nerve blocks in posterior approach surgery needs further study. In short, we were unable to adjust for the aforementioned confounding factors, therefore the impact of residual confounding on the current association results could not be ignored. Regarding adverse events, although the present study did not detect any incidence of local anesthetic toxicity or other rare complications such as infection or interference with wound healing, one limitation of the study is that our N may have been insufficient to rule them out. As our technique gains in popularity, it will be important to continue to monitor for adverse events. To further illustrate the efficacy and safety of QL and LFCN blocks in THA, we are presently in the process of recruiting for a single center randomized control study based on data from this study.[30]

5. Conclusions

This study indicated that the innovative utilization of motor sparing PNBs (transmuscular QL3/LFCN blocks) and a combination of DEX/MPA as local anesthetic adjuvants provided total hip arthroplasty patients with prolonged analgesia for up to 3 days, earlier discharge by one day and decreased hospitalization cost by 20%.

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References

1. Kukreja P, MacBeth L, Potter W, et al. Posterior quadratus lumborum block for primary total hip arthroplasty analgesia: a comparative study. Einstein (Sao Paulo). 9 2019;17(4):eAO4905. doi:10.31744/einstein_journal/2019AO4905 [PubMed: 31508661]
2. Kuchálik J, Magnuson A, Lundin A, Gupta A. Local infiltration analgesia or femoral nerve block for postoperative pain management in patients undergoing total hip arthroplasty. A randomized, double-blind study. Scand J Pain. 7 2017;16:223–230. doi:10.1016/j.sjpain.2017.05.002 [PubMed: 28850408]
3. Johnson RL, Amundson AW, Abdel MP, et al. Continuous Posterior Lumbar Plexus Nerve Block Versus Periarticular Injection with Ropivacaine or Liposomal Bupivacaine for Total Hip Arthroplasty: A Three-Arm Randomized Clinical Trial. J Bone Joint Surg Am. 11 2017;99(21):1836–1845. doi:10.2106/JBJS.16.01305 [PubMed: 29088038]
4. Johnston DF, Sondekoppam RV. Continuous quadratus lumborum block analgesia for total hip arthroplasty revision. J Clin Anesth. 12 2016;35:235–237. doi:10.1016/j.jclinane.2016.08.002 [PubMed: 27871532]
5. La Colla L, Ben-David B, Merman R. Quadratus Lumborum Block as an Alternative to Lumbar Plexus Block for Hip Surgery: A Report of 2 Cases. A A Case Rep. 1 1 2017;8(1):4–6. doi:10.1213/XAA.0000000000000406 [PubMed: 28036319]
6. Pehora C, Pearson AM, Kaushal A, Crawford MW, Johnston B. Dexamethasone as an adjuvant to peripheral nerve block. Cochrane Database Syst Rev. 11 2017;11:CD011770. doi:10.1002/14651858.CD011770.pub2 [PubMed: 29121400]
7. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 4 2008;61(4):344–9. doi:10.1016/j.jclinepi.2007.11.008 [PubMed: 18313558]
8. Vilhelmsen F, Nersesjan M, Andersen JH, et al. Lateral femoral cutaneous nerve block with different volumes of Ropivacaine: a randomized trial in healthy volunteers. BMC Anesthesiol. 8 2019;19(1):165. doi:10.1186/s12871-019-0833-4 [PubMed: 31455249]
9. Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. Journal of the Royal statistical society: series B (Methodological). 1995;57(1):289–300.

10. Kim JK, Ro DH, Lee HJ, Park JY, Han HS, Lee MC. Efficacy of Systemic Steroid Use Given One Day After Total Knee Arthroplasty for Pain and Nausea: A Randomized Controlled Study. J Arthroplasty. 1 2020;35(1):69–75. doi:10.1016/j.arth.2019.08.026 [PubMed: 31563397]
11. Nikolajsen L, Brandsborg B, Lucht U, Jensen TS, Kehlet H. Chronic pain following total hip arthroplasty: a nationwide questionnaire study. Acta Anaesthesiol Scand. 4 2006;50(4):495–500. doi:10.1111/j.1399-6576.2006.00976.x [PubMed: 16548863]
12. Guay J, Johnson RL, Kopp S. Nerve blocks or no nerve blocks for pain control after elective hip replacement (arthroplasty) surgery in adults. Cochrane Database Syst Rev. 10 31 2017;10:Cd011608. doi:10.1002/14651858.CD011608.pub2 [PubMed: 29087547]
13. Singelyn FJ, Ferrant T, Malisse MF, Joris D. Effects of intravenous patient-controlled analgesia with morphine, continuous epidural analgesia, and continuous femoral nerve sheath block on rehabilitation after unilateral total-hip arthroplasty. Reg Anesth Pain Med. 2005 Sep-Oct 2005;30(5):452–7. doi:10.1016/j.rapm.2005.05.008 [PubMed: 16135349]
14. Tetsunaga T, Sato T, Shiota N, Yoshida M, Okazaki Y, Yamada K. Comparison of Continuous Epidural Analgesia, Patient-Controlled Analgesia with Morphine, and Continuous Three-in-One Femoral Nerve Block on Postoperative Outcomes after Total Hip Arthroplasty. Clin Orthop Surg. 6 2015;7(2):164–70. doi:10.4055/cios.2015.7.2.164 [PubMed: 26217461]
15. Kukreja P, MacBeth L, Sturdivant A, et al. Anterior quadratus lumborum block analgesia for total hip arthroplasty: a randomized, controlled study. Reg Anesth Pain Med. 10 2019;doi:10.1136/rapm-2019-100804
16. Li J, Lam D, King H, Credaroli E, Harmon E, Vadivelu N. Novel Regional Anesthesia for Outpatient Surgery. Curr Pain Headache Rep. 8 1 2019;23(10):69. doi:10.1007/s11916-019-0809-6 [PubMed: 31372836]
17. Thybo KH, Schmidt H, Hägi-Pedersen D. Effect of lateral femoral cutaneous nerve-block on pain after total hip arthroplasty: a randomised, blinded, placebo-controlled trial. BMC Anesthesiol. 3 2016;16:21. doi:10.1186/s12871-016-0183-4 [PubMed: 27006014]
18. Ahsan ZS, Carvalho B, Yao J. Incidence of failure of continuous peripheral nerve catheters for postoperative analgesia in upper extremity surgery. J Hand Surg Am. 2 2014;39(2):324–9. doi:10.1016/j.jhsa.2013.11.011 [PubMed: 24480691]
19. Zhang X, Yang Q, Zhang Z. The efficiency and safety of local liposomal bupivacaine infiltration for pain control in total hip arthroplasty: A systematic review and meta-analysis. Medicine (Baltimore). 12 2017;96(49):e8433. doi:10.1097/MD.0000000000008433 [PubMed: 29245214]
20. Zamora FJ, Madduri RP, Philips AA, Miller N, Varghese M. Evaluation of the Efficacy of Liposomal Bupivacaine in Total Joint Arthroplasty. J Pharm Pract. 9 16 2019:897190019872577. doi:10.1177/0897190019872577
21. Kirkham KR, Jacot-Guillarmod A, Albrecht E. Optimal Dose of Perineural Dexamethasone to Prolong Analgesia After Brachial Plexus Blockade: A Systematic Review and Meta-analysis. Anesth Analg. 1 2018;126(1):270–279. doi:10.1213/ANE.0000000000002488 [PubMed: 28922230]
22. Shishido H, Kikuchi S, Heckman H, Myers RR. Dexamethasone decreases blood flow in normal nerves and dorsal root ganglia. Spine (Phila Pa 1976). 3 2002;27(6):581–6. doi:10.1097/00007632-200203150-00005 [PubMed: 11884905]
23. Johansson A, Hao J, Sjölund B. Local corticosteroid application blocks transmission in normal nociceptive C-fibres. Acta Anaesthesiol Scand. 7 1990;34(5):335–8. doi:10.1111/j.1399-6576.1990.tb03097.x [PubMed: 2167604]
24. Eker HE, Cok OY, Aribogan A, Arslan G. Management of neuropathic pain with methylprednisolone at the site of nerve injury. Pain Med. 3 2012;13(3):443–51. doi:10.1111/j.1526-4637.2011.01323.x [PubMed: 22313580]
25. Khan JS, Rai A, Sundara Rajan R, Jackson TD, Bhatia A. A scoping review of perineural steroids for the treatment of chronic postoperative inguinal pain. Hernia. 6 2016;20(3):367–76. doi:10.1007/s10029-016-1487-5 [PubMed: 27033854]
26. Shanahan EM, Ahern M, Smith M, Wetherall M, Bresnihan B, FitzGerald O. Suprascapular nerve block (using bupivacaine and methylprednisolone acetate) in chronic shoulder pain. Ann Rheum Dis. 5 2003;62(5):400–6. doi:10.1136/ard.62.5.400 [PubMed: 12695149]

27. Rijsdijk M, van Wijck AJ, Kalkman CJ, Yaksh TL. The effects of glucocorticoids on neuropathic pain: a review with emphasis on intrathecal methylprednisolone acetate delivery. Anesth Analg. 5 2014;118(5):1097–112. doi:10.1213/ANE.0000000000000161 [PubMed: 24781577]

28. Schering Corporation. Celestone Soluspan. [package insert]. U.S. Food and Drug Administration website. https://www.accessdata.fda.gov/drugsatfda_docs/label/2008/014602s047lbl.pdf. Revised 6 2008. Accessed December 2020.

29. Benzon HT, Chew TL, McCarthy RJ, Benzon HA, Walega DR. Comparison of the particle sizes of different steroids and the effect of dilution: a review of the relative neurotoxicities of the steroids. Anesthesiology. 2 2007;106(2):331–8. doi:10.1097/00000542-200702000-00022 [PubMed: 17264728]

30. ClinicalTrials.gov [Internet]. Bethesda (MD): National Library of Medicine (US). 2019 6 6 - . Identifier NCT03977454. [cited 2020 December 12]; available from https://clinicaltrials.gov/ct2/show/NCT03977454?term=nct03977454&draw=2&rank=1.

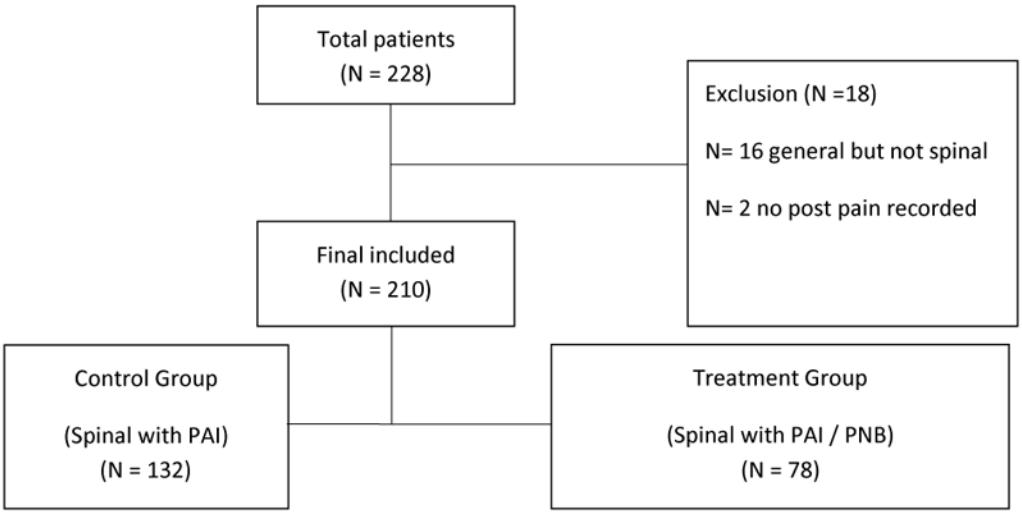

Figure 1.
Flowchart of screened and excluded patients.

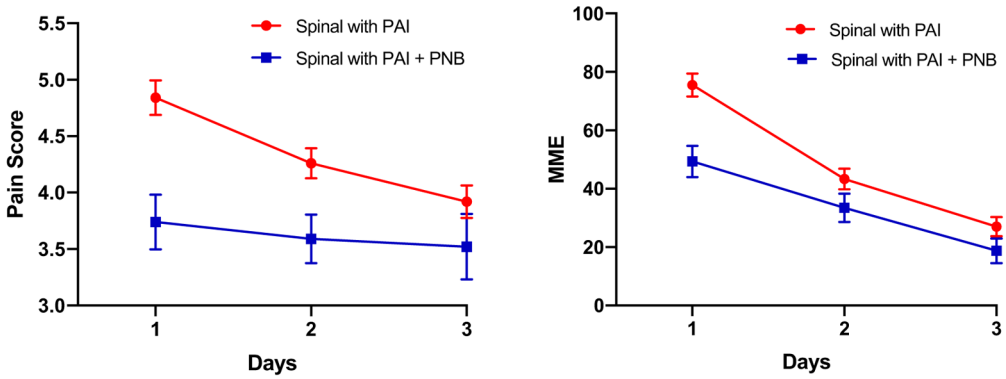

Figure 2.

The graphics represent the progression of VAS pain score (left) and opioid consumption (MME) (right) throughout the immediate postoperative period between the control (Spinal with PAI only) group and the treatment (Spinal with PAI and PNB) group.

MME: morphine milligram equivalent, PAI: periarticular injection, PNB: peripheral nerve block

Table 1.

Patient Demographics and Perioperative Characteristics

	Spinal with PAIControl	Spinal with PAI/PNBTreatment	Total	
Characteristics	**N=132**	**N=78**	**N=210**	**P-value**
Age	63.20 ± 11.23	62.14 ± 11.25	62.80 ± 11.22	0.51
Male Gender	54 (41%)	42 (54%)	96 (46%)	0.07
BMI	29.77 ± 6.88	29.05 ± 5.03	29.50 ± 6.25	0.76
Ethnicity				
Hispanic or Latino	6 (5%)	4 (5%)	10 (5%)	1.00
Non-Hispanic	126 (95%)	74 (95%)	200 (95%)	
ASA status				
1 – 2	82 (62%)	52 (67%)	134 (64%)	0.51
3 – 4	50 (38%)	26 (33%)	76 (36%)	
Surgical approach				
Anterior	115 (87%)	75 (96%)	190 (90%)	0.12
Lateral	8 (6%)	2 (3%)	10 (5%)	
Posterior	9 (7%)	1 (1%)	10 (5%)	
Preoperative MME	12.55 ± 29.10	16.51 ± 34.77	14.02 ± 31.31	0.38
Discharge MME	91.90 ± 49.80	81.74 ± 40.01	85.51 ± 44.06	0.13
Surgical duration in minutes	136.90 ± 59.02	155.72 ± 136.85	143.8± 95.74	0.22

Note: data are presented as mean ± SD, median (interquartile range: IQR), n (%)

MME: morphine milligram equivalent. PAI: Periarticular Injection. PNB: Peripheral Nerve Block.

Table 2.

Between-Group Comparisons of Primary Outcome and Secondary Outcomes

	Spinal with PAI/PNB	Spinal with PAI		
Outcomes	**(n = 78)**	**(n = 132)**	**Difference (95% CI)**	**P-value[b]**
Pain score				
POD 1[a]	3.74 (3.32 to 4.17)	4.84 (4.50 to 5.18)	−1.10 (−1.64 to −0.55)	<0.001
POD 2	3.59 (3.21 to 3.96)	4.26 (3.98 to 4.55)	−0.68 (−1.15 to −0.21)	0.007
POD 3	3.52 (3.07 to 3.97)	3.92 (3.63 to 4.22)	−0.40 (−0.93 to 0.14)	0.145
MME				
POD 1	49.33 (39.03 to 59.64)	75.52 (67.65 to 83.39)	−26.19 (−39.16 to −13.23)	<.001
POD 2	28.66 (18.91 to 38.4)	43.29 (36.46 to 50.12)	−14.64 (−26.54 to −2.73)	0.018
POD 3	9.18 (−0.92 to 19.28)	25.44 (19.61 to 31.27)	−16.26 (−27.92 to −4.60)	0.008
Disposition				
Home or self-care	30 (38%)	23 (17%)	NA	0.005
Home health services	38 (49%)	79 (60%)		
Skilled nursing facility	10 (13%)	30 (23%)		
Length of stay in days	1.36 ± 0.95	2.50 ± 1.38	−1.14 (0.82 to 1.46)	0.002

Note: data are presented as mean ± SD, least square mean and 95% CI are presented.

POD: Postoperative Day. PAI: Periarticular Injection. PNB: Peripheral Nerve Block. MME: milligram morphine equivalent

a: primary outcome

b: The p-value is after adjustment for false discovery rate on 9 comparisons using the Benjamini-Hochberg procedure