OPEN Research Article

Administration of Low-dose Hyperbaric Bupivacaine for Spinal Anesthesia in the Setting of Outpatient Arthroplasty

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ABSTRACT

Introduction: With the rise of ambulatory surgery centers (ASCs), rapid motor and sensory recovery after anesthesia is crucial. The purpose of this study was to evaluate the safety and efficacy of low-dose single-shot hyperbaric bupivacaine for spinal anesthesia (SA) for patients undergoing outpatient arthroplasty.

Methods: Data were reviewed from a single ASC from 2018 to 2020 for two arthroplasty-trained surgeons for all patients with primary arthroplasties that had administration of low-dose hyperbaric bupivacaine. Data collected from the ASC records were then further evaluated for total spinal block time, length of blockade, time to discharge criteria, visual analog scale (VAS) scores, and time to discharge.

Results: Two hundred twenty-seven patients undergoing 244 primary arthroplasties received SA with low-dose hyperbaric bupivacaine. The volume of 0.75% bupivacaine varied: 115 patients received 0.8 mL (6 mg), 111 patients received 1.0 mL (7.5 mg), and 17 patients received 1.2 mL (9 mg). Total SA time averaged 144 minutes with a mean of 30 minutes from post anesthesia care unit arrival to motor recovery. The mean time from post anesthesia care unit arrival to discharge criteria was 89 minutes. The average VAS at discharge was 1.44; the average VAS on POD1 was 3.0. No episodes of urinary retention and no reports of transient neurologic symptoms were noted in the study population.

Conclusion: Low-dose, single-shot hyperbaric bupivacaine SA is an effective option in the ASC for arthroplasty, providing a fast return of motor function, facilitating rapid discharge, and is safe with a relatively low-risk profile.

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Total joint arthroplasty (TJA) is expected to continue to have a rapid increase in case volume by 2030, with an increase of 75% in total hip arthroplasty (THA) and an increase of 182% in total knee arthroplasty (TKA).[1] Ambulatory surgery centers (ASCs) are an increasingly attractive

option, providing a lower-cost alternative while expanding the availability of operating rooms.[2]

With the rise of ASC volume, rapid motor and sensory recovery after anesthesia is crucial. The method of anesthesia administration during TJA varies. The administration of general anesthesia (GA) remains common and in some studies is the most prevalent,[3,4] although it has been associated with an increased risk of complications,[5,6] including increased nausea and pain in the recovery unit.[7,8] The alternative is spinal anesthesia (SA) which is growing in popularity for arthroplasty.[6,8,9] SA has been found to be equivalent without increased morbidity[10] and has been associated with lower blood loss, fewer rates of surgical site infection, and decreased overall rates of major and minor complications compared with GA.[9,11,12] Although GA continues to be tolerated at the ASC, this may be more due to the patient preselection than the anesthetic technique.[13] Owing to the possible increased complication profile, especially with minor complications affecting patient discharge readiness, SA has become an attractive option.

Multiple agents for spinal anesthesia are used at the discretion of the anesthesiologist, including lidocaine, mepivacaine, ropivacaine, and bupivacaine. Lidocaine has been previously associated with transient neurologic symptoms (TNS),[14] although a more recent study found no TNS in their patient population.[15] However, due to this underlying concern, other agents have been used recently. Among these, bupivacaine has become the preferred choice for SA with a long clinical history and has also been found to have preference toward a sensory blockade over a motor blockade.[16]

Bupivacaine may be prepared in various baricities about the cerebrospinal fluid: hypobaric, isobaric, and hyperbaric. Hyperbaric bupivacaine has been preferred because of its rapid onset, shorter duration of action, and rapid return of sensory and motor function.[17] Hyperbaric bupivacaine also has lower rates of high spinal when compared with other preparations.[18] Hyperbaric bupivacaine is also more potent than standard bupivacaine, facilitating lower doses for similar blockade.[19]

With increasing interest in the ASC center with rapid and safe patient discharge, we wanted to evaluate the utility of spinal anesthesia for outpatient arthroplasty. The purpose of this study was to evaluate the safety and efficacy of single-shot hyperbaric bupivacaine for SA for patients undergoing outpatient partial and TJA at a freestanding ASC. We hypothesized that patients undergoing this protocol would have a rapid discharge from the ASC and have a low adverse event profile.

Methods

Institutional review board approval was obtained before collection of retrospective and prospective data. Data were reviewed from a single ASC and included all patients aged 18 years or older from two arthroplasty-trained surgeons from 2018 to 2020. Of this patient population, all primary TKAs, primary THAs, and primary unicompartmental arthroplasties (UKAs) were included if they had administration of SA performed by the same anesthesiologist. Patients were excluded if they received general anesthesia from failed spinal anesthesia or if they received any form of revision arthroplasty. Patients were also excluded if they had a BMI greater than 45, history of drug or alcohol use, chronic opioid use (defined as consumption greater than 6 months preoperatively), and a nonambulatory status at baseline.

All included patients received either 0.8, 1.2, or 2.0 mL of 0.75% hyperbaric bupivacaine along with concomitant titrated propofol sedation. No other types of spinal blocks were administered during the study period. Bupivacaine dosage was determined by the anesthesiologist to provide the appropriate duration of pain relief compared with historic surgical times of the operating surgeon, with other adjustments based on extremes in patient height. Periarticular blocks varied by the surgeon protocol, but no regional blocks were done. Data collected from the ASC records were then further evaluated for demographic data (including age, sex, and BMI), total SA time, length of sensory and motor blockade, time to ambulation, visual analog scale (VAS) scores, and time to discharge. Discharge criteria included the following: medically stable, able to void, pain control, ability to tolerate a regular diet, independently navigate from bed to chair and chair to ambulation transition, independently walk with or without an assist device 100 feet, and ascend and descend a full staircase. Postoperative data were then collected over the phone by nursing staff on postoperative day (POD) 1 which included VAS score and overall satisfaction with pain control. Means, ranges, and standard deviations were calculated for the data set. All descriptive statistics were calculated using Microsoft Excel.

Results

Ultimately, 227 patients undergoing 244 primary arthroplasties, received SA administration of single-shot low-dose hyperbaric bupivacaine and met inclusion criteria. This included 66 TKAs (27%), 138 medial

UKAs (56%), 19 lateral UKAs (7.7%), 3 patellofemoral arthroplasties (1.2%), and 18 THAs (7.3%). The average age of the patients in the study population was 61 years old. Male patients and female patients composed 54% and 46% of the cases, respectively. The average BMI of patients in the study was 31.33. The volume of 0.75% bupivacaine varied, 115 patients receiving 0.8 mL (6 mg), 111 patients receiving 1.0 mL (7.5 mg), and 17 patients receiving 1.2 mL (9 mg) (Supplemental Table 1, http://links.lww.com/JG9/A344).

Total time of SA was defined as the difference between spinal administration to motor recovery in the post anesthesia care unit (PACU). For the study population, total SA time averaged 144 minutes (+± 42 minutes). The mean time from PACU arrival to motor recovery was 30 minutes. This was further analyzed and differentiated between arthroplasty type: 28 minutes for TKA patients, 29 minutes for UKA/PFA patients, and 48 minutes for THA patients. The mean time from PACU arrival to the patient meeting discharge criteria was 89 minutes (± 38 minutes). The total time spent in the PACU at the ASC was 112 minutes (± 40 minutes).

VAS pain scores were evaluated at the time of discharge and by telephone on POD1. The average VAS at time of discharge was 1.44, and the average VAS on POD1 was 3.0. When analyzed by the procedure, the average VAS scores on discharge for TKA, THA, and UKA were 2.33, 2.07, and 1.10, respectively. The average VAS scores on POD1 for TKA, THA, and UKA were 3.17, 3.36, and 2.79, respectively. The average VAS on discharge by dose of bupivacaine was 1.47 for 0.8 mL, 1.47 for 1.0 mL, and 1.18 for 1.2 mL. The average VAS on POD1 by dose of bupivacaine was 3.0 for 0.8 mL, 2.8 for 1.0 mL, and 4.1 for 1.2 mL (Supplemental Table 2, http://links.lww.com/JG9/A345).

Regarding complications, one patient experienced a vasovagal syncopal event in PACU. Another patient had pain and difficulty ambulating and was discharged in a wheelchair. One report of a patient with episodes of incontinence was noted. No episodes of urinary retention and no reports of TNS were noted in the study population.

Discussion

Total joint arthroplasty volume is shifting to outpatient settings such as hospital outpatient departments and freestanding ambulatory surgery centers (ASCs). Recent estimates are projecting that more than 50% of primary joint arthroplasty will occur in an outpatient center by 2026.[20] Because of this, many studies have been done to find surgical techniques, preoperative protocols, analgesic control, patient risk factors, and postoperative methods decreasing the length of stay and allowing same-day discharge in the ASC setting. Our study seeks to contribute to this body of knowledge, specifically regarding the anesthetic technique in outpatient TJA.

The low-dose hyperbaric bupivacaine spinal used in this study was effective at providing appropriate anesthesia and facilitated timely discharge. Patients had a relatively fast return to motor function at 114 minutes and had an average time to motor recovery in the PACU of 30 minutes. Using the previously stated discharge criteria, the average time to criteria met in PACU was 89 minutes with average total length of stay being 112 minutes. We believe that this demonstrates SA with low-dose bupivacaine can facilitate rapid recovery in the ASC setting, with a relatively low-risk profile.

As previously mentioned, bupivacaine is available in multiple baricities: hypobaric, isobaric, and hyperbaric. The baricity of bupivacaine also affects the mean effective dose (ED50), with hyperbaric bupivacaine having the lowest ED50 required for a block. Hyperbaric bupivacaine also has faster onset and quicker recovery when compared with isobaric bupivacaine.[19] Another important property in bupivacaine is that the ED50 generally decreases with age, important in the total joint population.[21] A Cochrane systematic review comparing hyperbaric versus isobaric bupivacaine showed that with hyperbaric bupivacaine, there were decreased conversion to general anesthesia, less need for supplemental analgesia, and no differences in the prevalence of nausea.[22] In a systematic review and meta-analysis of randomized controlled trials of noncesarean surgeries from 1946 to 2016 found that in 724 participants, hyperbaric bupivacaine resulted in a faster onset of motor blockade and a quicker return to motor and sensory function compared with isobaric bupivacaine.[17]

Other spinal anesthetics have also been used for joint arthroplasty. Lidocaine had been previously used with great efficacy, although there has been hesitation due to the potential risk of TNS with lidocaine, which has been shown to be 7.31 times more likely when compared with other agents such as bupivacaine.[14] However, one study found that low-dose lidocaine SA in a 50 patient cohort had no TNS. Interestingly, in that same study, the average motor block was 173 minutes and average time to motor recovery in PACU was 35 minutes.[15] Our study demonstrated that low-dose hyperbaric bupivacaine had quicker recovery times, with an average

motor block 114 minutes and average motor recovery in PACU of 30 minutes.

Mepivacaine is another anesthetic that has been used for spinal anesthesia. One study of 32 TKAs comparing mepivacaine versus hyperbaric bupivacaine demonstrated that mepivacaine had a faster return of sensory function (164 vs 212 minutes, P = 0.15) and a faster return of motor function (153 vs 200 minutes, P = 0.25), resulting in faster discharge readiness. The mepivacaine group demonstrated less urinary retention, higher VAS pain scores in PACU, and no difference in opioid utilization. Neither group had required conversion to general anesthesia nor reported TNS.[23] By contrast, our study found a return to motor function of 144 minutes with hyperbaric bupivacaine, which may be attributed to the lower dose of 0.8 to 1.2 mL of 0.75% bupivacaine in our study as compared with the 1.4 to 1.6 mL found in the previous study.

A randomized controlled trial compared mepivacaine with hyperbaric bupivacaine in 154 total hip arthroplasties. Doses used were mepivacaine 1.5% (3.5 mL, 52.5 mg), hyperbaric bupivacaine 0.75% (1.5 mL, 11.25 mg), or isobaric bupivacaine 0.5% (2.5 mL, 12.5 mg). Their primary outcome was ambulation between 3 and 3.5 hours after SA. Mepivacaine achieved this time window 70% of time, hyperbaric bupivacaine 37.7% of the time, and isobaric bupivacaine 17.6% of the time. However, patients who received mepivacaine showed a markedly greater PACU opiate consumption than the other two anesthetics. Each group had incidence of TNS with no notable difference between groups, and there was no incidence of discharge home with foley catheter.[24] Again, in contrast to our study, a much higher dosage of bupivacaine was administered, so their results may not be comparable.

A different randomized controlled trial compared differences of three hyperbaric spinal anesthetics on 60 patients. Patients received either 3 mL of hyperbaric ropivacaine, bupivacaine, or levobupivacaine, all 5 mg/mL concentration. Ropivacaine was found to have faster return of motor function (90 mins) than both levobupivacaine and bupivacaine (180 mins). Ropivacaine had a shorter time to ambulation of 218 mins versus the other compounds, 306 mins for bupivacaine and 286 mins for levobupivacaine. No anesthetic group had any incidence of urinary retention or TNS.[25] Again, the dosage used for hyperbaric bupivacaine was 15 mg, which is markedly higher than our study with the dosages varying from 6.5 to 9 mg.

Strengths of our study include the sample size, consistency, and recording of the dose of anesthetic administered, and consistent administration of SA because it was done by a single anesthesiologist. We also believe that having a single ASC with consistent anesthesia adds to the case consistency and eliminates potential variability. One potential weaknesses of our study could be the accuracy recording time to motor recovery by PACU staff. Their protocol is based on the Aldrette score, and as such is only recorded in 15-minute intervals. Data for time to ambulation were not available. Owing to this, there remains a discrepancy between return of motor function and the time that discharge criteria were met. In addition, it is acknowledged that in the ASC setting, surgical times may vary compared with hospital-based procedures and as such additional duration of anesthesia may be required in those settings. In tandem with this, this may limit some of the generalizability based on surgeon-specific surgical times. Finally, by the nature of the study design, there is no direct comparison cohort, which may be a valuable comparison when considering a change to low-dose bupivacaine in practice. Having a comparison group with general anesthesia and other spinal anesthetics may be useful for future research to determine additional applicability.

Conclusion

Low-dose, single-shot hyperbaric bupivacaine spinal anesthesia is an effective option in the ambulatory surgery environment. It provides adequate anesthesia for outpatient arthroplasty, has a fast return of sensory and motor function, facilitates rapid time to discharge, and is safe with a relatively low-risk profile.

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