IMPACT OF AGE, GENDER AND ANESTHESIA MODALITY ON POST-OPERATIVE PAIN IN TOTAL KNEE ARTHROPLASTY PATIENTS

David Pope, MD, Mouhanad M. El-Othmani, MD, Blaine T. Manning, BS, Mykel Sepula, BS, Stephen J. Markwell, MA, Khaled J. Saleh, BSc MD MSc FRCS(C) MHCM

ABSTRACT

Background: Optimizing pain control following total knee arthroplasty is of utmost importance to the immediate post-operative course. Various anesthesia modalities are available, but studies comparing multiple anesthesia modalities, patient age, and sex are limited.

Questions/Purpose: The purpose of our study was to examine the impact of patient age, gender, and perioperative anesthesia modality on postoperative pain following primary total knee arthroplasty.

Methods: 443 patients who underwent primary total knee arthroplasty by 14 surgeons with some combination of general anesthesia, spinal anesthesia, femoral nerve block, and intrathecal morphine were identified. Anesthesia route and type, length of surgery, post-operative patient-reported pain measures using the Visual Analog Scale, opioid consumption, and length of hospital stay were recorded for each patient and used to compare differences among study groups.

Results: No significant differences were noted between anesthesia groups with regards to post-operative pain or length of hospital stay. Patients receiving spinal anesthesia and femoral nerve block without intrathecal morphine were significantly older than other groups. Patients receiving general anesthesia required significantly more daily intravenous morphine equivalents than patients receiving spinal anesthesia. Patients receiving spinal anesthesia with femoral nerve block and intrathecal morphine consumed the least amount of morphine equivalents. When comparing males and females among all groups, females had significantly higher pain ratings between 24-36 and 24-48 hours post-operatively.

Conclusion: Although no significant differences were noted on pain scores, patients who received spinal anesthesia with intrathecal morphine and femoral nerve block used less narcotic pain medication than any other group. Females reported significantly higher pain between 24-48 hours post-op compared with males but not significantly greater anesthetic usage.

Level of Evidence: Level III, Therapeutic Study, (Retrospective Comparative study)

Keywords: Total knee arthroplasty, Pain control, Anesthesia, Gender

INTRODUCTION

By 2030, the demand for total knee arthroplasty (TKA) in the United States is projected to reach 3.48 million procedures annually[1,2]. While the efficacy and safety of TKA is well-known, adequate postoperative pain relief is essential in order to ensure a rapid recovery[3,4]. In order to achieve maximum benefit from primary TKA, proper pain management begins during perioperative anesthesia.

However, a variety of anesthesia modalities for TKA are available for patients and physicians. General anesthesia has long been the standard regimen for TKA pain management and affords significant patient benefits. With general anesthesia, patients are allowed amnesia of the entire procedure while physicians maintain complete control over the airway and circulation of the patient. However, general anesthesia is associated with higher postoperative pain and longer postoperative rehabilitation when compared to regional anesthesia/analgesia[5].

In response to the shortcomings of general anesthesia, regional anesthesia has become a viable option for pain management in TKA patients. Spinal anesthetics offer rapid onset, minimal systemic toxicity, and a prolonged duration of anesthesia into the postoperative period[6]. The use of femoral nerve block (FNB) as a supplement to general or spinal anesthesia has also been explored for TKA use. Studies have found that patients receiving an FNB with general anesthesia used less postoperative morphine and had significant pain relief compared to those who did not[2,7]. In addition to combining spinal anesthesia with a FNB, it is also pos-

Division of Orthopaedics and Rehabilitation
Department of Surgery
Southern Illinois University School of Medicine

Corresponding Author:
Khaled J. Saleh, BSc MD MSc FRCS(C) MHCM
Division of Orthopedics and Rehabilitation
Southern Illinois University School of Medicine
P.O. Box 19679
Springfield, IL 62794-9679, USA
Tel: (217) 545-8865
Fax: (217) 545-7901
E-mail: ksaleh@siumed.edu

sible to combine spinal anesthesia, FNB, and intrathecal morphine. Fischer et al showed that rescue analgesic use was lower in patients who received spinal anesthesia with an opioid supplement[2].

Currently, there is a lack of literature regarding the impact of gender and anesthesia modality on post-operative pain in patients undergoing TKA. The purpose of our study was to determine if anesthesia modality and patient gender impact postoperative pain following primary TKA. We hypothesized that the use of intrathecal morphine with FNB would have the greatest analgesic efficacy as shown through patient-reported pain scores and opioid consumption. We also hypothesized that there would be no difference between pain scores and morphine consumption between males and females in the immediate post-operative period.

MATERIAL AND METHODS

Investigational Review Board (IRB) approval was obtained by the Committee for Research Involving Human Subjects for this study. Using CPT code 27447, 443 patients who had undergone primary total knee arthroplasty at Memorial Medical Center in Springfield, IL from March 2010 through September 2010 were retrospectively identified. Fourteen different surgeons performed the operations. Using the patient's hospital identification number, baseline demographic information was extracted, including: age, gender, and comorbidities. Inpatient information, including: anesthesia route and type, length of surgery, post-operative patient-reported pain measures using the Visual Analog Scale (VAS), opioid consumption (which included IV-PCA, IV nurse given, and oral), and length of hospital stay were also collected.

Nurses obtained the VAS scores, post-operatively, before opioid administration. Patients were asked to designate what magnitude of pain they were experiencing with zero representing no pain and ten representing the worst possible pain. The VAS was administered by nursing staff at 21:00 hours (+/-5 hours) on post-operative day one, as this is the time when the anesthesia is typically out of the patient's system. However, TKA patients are often sleeping during the post-operative timeframe of 21:00 hours +/- 5 hours. Therefore, average VAS scores between 24-36 hours and 24-48 hours postoperative were also calculated for analysis.

Due to the expected variation in opioids given to patients, the morphine equivalent was calculated. Initially, the total amount of a specific IV opioid was multiplied by its conversion factor to find an equianalgesic equivalent with 10mg of morphine as the standard[8,9]. All drug equivalents were then totaled to determine the total IV opioid equianalgesic dosage. Oral opioid equianalgesic dosage was calculated using conversion factors specific to oral medications. After multiplying the total amount of a specific narcotic by its conversion factor, that number was multiplied by the morphine oral-to-IV conversion factor to obtain the IV equivalent. The drugs' IV equivalents were summed to obtain a final equivalent value. The final step was to add the total IV opioid equianalgesic dosage to the total oral opioid equianalgesic dosage. This final number is the total amount of opioids delivered to the patient in IV equivalents. In accordance with hospital policy, the duramorph group did not receive any oral narcotics until 16 hours postoperatively, and no IV narcotics were given until post-op day one.

The data was de-identified, using sequential study numbers, prior to any data analysis. Means and standard deviations or medians and interquartile ranges (IQR) are reported for continuous variables, while frequencies and percentages are reported for categorical variables. Analyses of variance (ANOVAs) were used to compare the three groups on age, length of surgery, length of stay and the ratings of pain. Because of distributional characteristics, non-parametric Kruskal-Wallis tests were used to compare the groups on their daily usage of morphine equivalents. Chi-square tests of independence were used to compare the groups on gender and on comorbidities. Results were considered statistically significant for $p < 0.05$. Pair-wise follow-up comparisons were performed in the presence of statistically significant overall tests. All analyses were performed using SAS v9.2 software (SAS Institute Inc., Cary, NC, USA).

3.0 Results

Of the 443 TKA patient charts that were reviewed, 27 received general anesthesia without intrathecal morphine (DURAMORPH©; Baxter, Deerfield, IL, USA) or femoral nerve block, 37 received general anesthesia and femoral nerve block without intrathecal morphine, 17 received spinal anesthesia without intrathecal morphine or femoral nerve block, 77 received spinal anesthesia and femoral nerve block without intrathecal morphine, 18 received spinal anesthesia and intrathecal morphine without femoral nerve block, and 267 received spinal anesthesia with intrathecal and femoral nerve block.

Intergroup Comparisons

No significant differences were noted between the anesthesia groups with regards to postoperative pain or length of hospital stay. Patients receiving spinal anesthesia and femoral nerve block without intrathecal morphine were significantly older (69.8±10.8) than those receiving general anesthesia without intrathecal morphine or femoral nerve block (62.3±10.2), and those receiving spinal anesthesia with intrathecal morphine and femoral nerve block (65.8±9.9) ($p<0.05$).

Table 1: The prevalence of comorbidities and other factors that may contribute to post-operative pain within each group are listed.

	General (n=27)	General with Femoral nerve block(n=37)	Spinal (n=17)	Spinal with Femoral nerve block (n=77)	Spinal with Intrathecal morphine, (n=18)	Spinal with Intrathecal morphine and Femoral nerve block (n=267)	p-value
Cardiac Disease	23 (85.2%)	35 (94.6%)	15 (88.2%)	66 (85.7%)	13 (72.2%)	237 (88.8%)	0.262
Sleep Apnea	7 (25.9%)	6 (16.2%)	9 (53.0%)	13 (16.9%)	4 (22.2%)	57 (21.6%)	0.038
Mental Disorder	7 (26.0%)	7 (19.0%)	4 (23.5%)	14 (18.2%)	6 (33.3%)	51 (19.1%)	0.695
Pulmonary Disorder	9 (33.3%)	12 (32.4%)	4 (23.5%)	20 (26.0%)	2 (11.1%)	73 (27.3%)	0.614
Obesity	11 (40.7%)	10 (27.0%)	4 (23.5%)	20 (26.0%)	6 (33.3%)	73 (27.3%)	0.726
Endocrine Disorder	11 (40.7%)	16 (43.2%)	6 (35.3%)	34 (44.2%)	3 (16.7%)	90 (33.7%)	0.232
Male Patients	11 (40.7%)	12 (32.4%)	7 (41.2%)	24 (31.2%)	7 (38.9%)	107 (40.1%)	0.751

Of the 27 patients receiving general anesthesia without intrathecal morphine or femoral nerve block, 11 were male (40.7%). Twelve of the 37 patients (32.4%) receiving general anesthesia and femoral nerve block without intrathecal morphine were male. Seven of the 17 patients (41.2%) receiving spinal anesthesia without intrathecal morphine or femoral nerve block were male. Twenty-four of the 77 patients (31.2%) receiving spinal anesthesia and femoral nerve block without intrathecal morphine were male. Seven of the 18 patients (38.9%) receiving spinal anesthesia and intrathecal morphine without femoral nerve block were male. Of the 267 patients undergoing spinal anesthesia with intrathecal morphine and femoral nerve block, 107 were male (40.1%).

As noted in Table 1, patients undergoing each of the six TKA anesthesia regimens were similar with regards to the prevalence of comorbidities. The sole significant difference regarded sleep apnea, where more patients receiving spinal anesthesia without intrathecal morphine or femoral nerve block had sleep apnea (53.9%) than TKA

Table 2: The primary outcomes listed by anesthesia group

	General (n=27)	General with Femoral nerve block(n=37)	Spinal anesthesia (n=17)	Spinal with Femoral nerve block (n=77)	Spinal with Intrathecal morphine, (n=18)	Spinal with Intrathecal morphine and Femoral nerve block (n=267)	p-value
Total surgery time (min) – mean±std	89.6±24.7	80.2±24.5	87.4±29.4	65.4±18.7	98.8±29.4	82.5±22.4	<0. 001
Age (years)	*62.30±10.15*	*66.92±10.65*	64.00±11.83	69.81±10.81	64.44±10.95	65.75±9.90	
Length of hospital stay (days) – mean±std	2.9±1.1	3.1±1.2	2.8±0.8	2.8±0.9	3.3±1.0	2.8±1.0	0.223
Average daily IV morphine equivalents consumption (mg) – median (IQR)	13.7 (2.5-53.4)	10.0 (0.0-106.7)	3.7 (0.0-18.5)	3.0 (0.0-65.7)	0.8 (0-55.3)	0.3 (0-405.3)	<0. 001
Average daily oral morphine equivalents consumption (mg) – median (IQR)	13.8 (2.1-54.6)	18.2 (0-178.8)	17.1 (7.7-38.1)	17.2 (0-417.7)	11.1 (1.7-53.0)	10.8 (0-50.8)	<0. 001
Average total daily morphine equivalents consumption (mg) – median (IQR)	31.6 (4.6-62.9)	28.3 (0-193.4)	23.3 (7.7-42.6)	22.1 (0.6-421.4)	18.8 (3.1-65.5)	11.6 (0-456.4)	<0. 001
VAS Score (21:00 ± 5 hrs postoperative day 1) – mean±std	4.00±2.13	3.93±2.02	3.50±1.76	3.40±2.20	3.67±3.04	3.38±2.06	0.855
Average VAS Score, 24-36 hours postoperative – mean±std	6.17±1.61	5.68±1.62	5.36±1.56	5.65±1.46	6.07±2.05	5.70±1.63	0.585
Average VAS Score, 24-48 hours postoperative – mean±std	5.94±1.57	5.49±1.47	5.59±1.13	5.51±1.26	5.76±1.87	5.48±1.43	0.687

patients receiving spinal anesthesia and femoral nerve block without intrathecal morphine (16.9%, p=0.038).

Furthermore, as shown in Table 2, there were significant differences between groups with regards to skin to skin operative time. Follow-up statistical tests indicated that patients receiving spinal anesthesia and femoral nerve block without intrathecal morphine had significantly shorter operative times (65.4±18.7 min) than TKA patients receiving: general anesthesia without femoral nerve block or intrathecal morphine (89.6±24.7 min), general anesthesia and femoral nerve block without intrathecal morphine (80.2±24.5 min), spinal anesthesia without intrathecal morphine or femoral nerve block (87.4±29.4 min), or spinal anesthesia and intrathecal morphine without femoral nerve block (98.8±29.4 min) (p<0. 001). Follow-up statistical tests revealed that patients receiving spinal anesthesia with intrathecal morphine and femoral nerve block had significantly shorter surgery times (82.5±22.4 min) than those receiving spinal anesthesia and intrathecal morphine without femoral nerve block (98.8±29.4 min) (p<0. 001).

Table 2 also shows that postoperative pain medication usage in terms of daily IV morphine equivalents differed statistically between the groups (p<0.001). Follow-up comparisons indicated that patients receiving: general anesthesia without femoral nerve block or intrathecal morphine (13.7 mg, range 2.5-53.4); and general anesthesia and femoral nerve block without intrathecal morphine (10.0 mg, range 0.0-106.7), required significantly more daily IV morphine equivalents than patients receiving: spinal anesthesia and femoral nerve block without intrathecal morphine (3.0 mg, range 0.0-65.7), spinal anesthesia and intrathecal morphine without femoral nerve block (0.8 mg, range 0-55.3), and spinal anesthesia with intrathecal morphine and femoral nerve block (0.3 mg, range 0-405.3) (p<0. 001). Patients receiving general anesthesia without femoral nerve block or intrathecal morphine required significantly more daily IV morphine equivalents than patients receiving spinal anesthesia without intrathecal morphine or femoral nerve block (13.7 (2.5-53.4) mg vs. 3.7 (0.0-18.5) mg, p<0. 001). Additionally, patients receiving spinal anesthesia with intrathecal morphine and femoral nerve block consumed significantly fewer daily IV morphine equivalents (0.3 (0-405.3) mg) than those receiving: spinal anesthesia without intrathecal morphine or femoral nerve block (3.7 (0.0-18.5) mg); and spinal anesthesia and femoral nerve block without intrathecal morphine (3.0 (0.0-65.7) mg).

Daily average oral morphine equivalent consumption among patients receiving spinal anesthesia with intrathecal morphine and femoral nerve block (10.8 (0-50.8) mg) was significantly lower than patients receiving: general anesthesia and femoral nerve block without intrathecal morphine (18.2 (0-178.8) mg), spinal anesthesia without intrathecal morphine or femoral nerve block (17.1 (7.7-38.1) mg), and spinal anesthesia and femoral nerve block without intrathecal morphine (17.2 (0-417.7) mg) (p<0. 001).

Daily average total morphine equivalent consumption also differed significantly among anesthesia groups. Patients receiving spinal anesthesia with intrathecal morphine and femoral nerve block consumed significantly less daily morphine equivalents (11.6 (0-456.4) mg) than those receiving: general anesthesia without femoral nerve block or intrathecal morphine (31.6 (4.6-62.9) mg), general anesthesia and femoral nerve block without intrathecal morphine (28.3 (0-193.4) mg), spinal anesthesia without intrathecal morphine or femoral nerve block (23.3 (7.7-42.6) mg), and spinal anesthesia and femoral nerve block without intrathecal morphine (22.1 (0.6-421.4) mg) (p<0. 001).

Intragroup Comparisons

(Table 3). Among patients receiving general anesthesia without intrathecal morphine or femoral nerve block, females reported significantly higher mean VAS scores than males between 24-48 hours postoperatively (6.5±1.7 vs. 5.1 ± 1.1, p=.057) and 24-36 hours postoperatively (7.1±1.6 vs. 5.1 ± 0.8, p<.001). Females receiving general anesthesia and femoral nerve block without intrathecal morphine consumed significantly more daily average morphine equivalents (21.5 (0.0-178.8) mg) than males (10.0 (2.5-25.7) mg, p=.027).

Compared to females, males receiving spinal anesthesia and intrathecal morphine without femoral nerve block experienced significantly shorter surgery times (115.6 ± 29.2 min vs. 88.1 ± 25.2 min, p<0.05). Surgery time for males receiving spinal anesthesia and intrathecal morphine without femoral nerve block (87.7 ± 26.1 min) was significantly longer compared to respective female patients (79.1 ± 18.9 min, p<.05). Furthermore, among patients receiving spinal anesthesia and intrathecal morphine without femoral nerve block, mean VAS ratings were significantly higher for females than males in both 24-48 hours postoperatively (5.7 ± 1.5 vs. 5.2 ± 1.2, respectively, p<.05) and from 24-36 hours postoperatively (5.9 ± 1.7 vs. 5.4 ± 1.5, respectively, p<.05).

Female patients across all anesthesia groups were similar with regards to length of stay and age. The only significant difference in VAS scores was found in average pain ratings during 24-36 hours postoperative, where females receiving general anesthesia without intrathecal morphine or femoral nerve block reported significantly more pain (7.0 ± 1.6) than females receiving spinal anesthesia and femoral nerve block without intrathecal morphine (5.6 ± 1.4, p<.05). Females receiving spinal anesthesia and femoral nerve block without intrathecal

Table 3: The primary outcomes listed by gender

	Males (n=168)	Females (n=275)	p-value
Age (years) – mean±std	66.8±9.7	65.9±10.8	0.384
Total surgery time (min) – mean±std	86.4±26.6	77.2±21.5	<0.001
Length of hospital stay (days) – mean±std	2.8±1.1	2.9±0.9	0.419
Average daily IV morphine equivalents (mg) – median (IQR)	0.7 (0-106.7)	0.7 (0.0-405.5)	0.653
Average daily oral morphine equivalents (mg) – median (IQR)	12.3 (0.0-121.3)	12.7 (0-417.7)	0.419
Average daily total morphine equivalents (mg) – median (IQR)	16.5 (0.4-187.0)	15.5 (0-456.4)	0.880
VAS score (21:00 ± 5 hrs on postoperative day 1) – mean±std	3.3±2.0	3.64±2.19	0.217
Average VAS score (24-36 hrs postoperative) – mean±std	5.4±1.6	5.93±1.61	0.001
Average VAS score (24-48 hrs postoperative) – mean±std	5.2±1.4	5.73±1.40	<0.001

morphine had significantly shorter surgery times (63.7 ± 17.0 min) than those female patients receiving: general anesthesia without femoral nerve block or intrathecal morphine (86.5 ± 26.3 min), general anesthesia and femoral nerve block without intrathecal morphine (78.2 ± 27.1 min), spinal anesthesia without intrathecal morphine or femoral nerve block (88.4 ± 27.0 min), spinal anesthesia and intrathecal morphine without femoral nerve block (88.1 ± 25.2 min), and spinal anesthesia with intrathecal morphine and femoral nerve block (79.1 ± 18.9 min) (p<0.0001).

Significantly more daily IV morphine equivalents were required among female patients receiving general anesthesia without femoral nerve block or intrathecal morphine (12.1 (2.5-53.4) mg) and general anesthesia and femoral nerve block without intrathecal morphine (10.3 (0.0-27.8) mg) compared to those female patients receiving: spinal anesthesia and femoral nerve block without intrathecal morphine (3.0 (0.0-23.0) mg), spinal anesthesia without intrathecal morphine or femoral nerve block (2.0 (0.0-11.0) mg), spinal anesthesia and intrathecal morphine without femoral nerve block (0.7 (0.0-55.3) mg), and spinal anesthesia with intrathecal morphine and femoral nerve block (0.3 (0-405.5) mg), (p<0.0001). Daily IV morphine equivalent was significantly higher among females receiving spinal anesthesia and femoral nerve block without intrathecal morphine (3.0 (0.0-23.0) mg) compared to those receiving spinal anesthesia with intrathecal morphine and femoral nerve block (0.3 (0-405.5) mg), (p<0.0001). Female patients receiving spinal anesthesia with intrathecal morphine and femoral nerve block consumed significantly less daily oral morphine equivalents (10.8 (0.0-50.8) mg) than those receiving general anesthesia and femoral nerve block without intrathecal morphine (21.5 (0.0-178.8) mg) or spinal anesthesia and femoral nerve block without intrathecal morphine (17.2 (0.0-417.7) mg) (p<0.0001). Finally, females receiving spinal anesthesia with intrathecal morphine and femoral nerve block consumed significantly fewer daily total morphine equivalents (11.4 (0.0-456.4) mg) compared to those receiving general anesthesia without femoral nerve block or intrathecal morphine (31.8 (13.1-62.9) mg), general anesthesia and femoral nerve block without intrathecal morphine (30.9 (0.0-193.4) mg), or spinal anesthesia and femoral nerve block without intrathecal morphine (22.6 (0.6-421.4) mg) (p<0.0001).

Across anesthesia groups, there were no differences between males regarding VAS scores, length of stay, or age. Surgery time was significantly shorter for males receiving spinal anesthesia and femoral nerve block without intrathecal morphine (69.3 ± 21.8 min) compared to those receiving spinal anesthesia and intrathecal morphine without femoral nerve block (115.6 ± 29.2 min) or spinal anesthesia with intrathecal morphine and femoral nerve block (87.7 ± 26.1 min) (p=0.001).

With regard to daily IV morphine equivalent consumption, males receiving spinal anesthesia with intrathecal morphine and femoral nerve block consumed significantly less (0.2 (0.0-90.9) mg) compared to those receiving: general anesthesia without femoral nerve block or intrathecal morphine (14.7 (2.5-27.7) mg), spinal anesthesia without intrathecal morphine or femoral nerve block (6.5 (1.0-18.5) mg), or spinal anesthesia and femoral nerve block without intrathecal morphine (3.3 (0.0-65.7) mg) (p<0.0001). Furthermore, males receiving general anesthesia without femoral nerve block or intrathecal morphine consumed significantly more daily

IV morphine equivalents (14.7 (2.5-27.7) mg) than those receiving spinal anesthesia and femoral nerve block without intrathecal morphine (3.3 (0.0-65.7) mg) ($p<0.0001$).

Daily oral morphine equivalent consumption was significantly greater among males receiving spinal anesthesia and femoral nerve block without intrathecal morphine (18.1 (0.0-121.3) mg) compared to those receiving spinal anesthesia with intrathecal morphine and femoral nerve block (11.0 (0.0-43.0) mg) ($p<.05$). Total daily morphine equivalent consumption was significantly less among males receiving spinal anesthesia with intrathecal morphine and femoral nerve block (12.8 (0.4-117.9) mg) compared to those receiving: general anesthesia without femoral nerve block or intrathecal morphine (28.4 (4.6-59.1) mg), spinal anesthesia without intrathecal morphine or femoral nerve block (26.5 (19.3-42.6) mg), and spinal anesthesia and femoral nerve block without intrathecal morphine (19.5 (8.6-187.0) mg) ($p<0.0001$).

DISCUSSION

Data exploring post-operative pain control after total knee arthroplasty with regard to anesthesia modality and gender remains limited. Pain control after surgery is vital for both patient satisfaction and early rehab. This study's aim was to answer which anesthesia modality provides for optimal pain control post-operatively as well as if gender or age plays a role in post-operative pain control.

Femoral nerve blocks and intrathecal morphine in isolation have been proven effective in post-operative pain control[10-15]. There is limited literature on combining both intrathecal morphine and femoral nerve blocks in concert with spinal anesthesia. In our study, patients receiving spinal anesthesia with FNB and intrathecal morphine injections used the least amount of morphine equivalents in the post-operative period. Consistent with previously reported results, patients receiving general anesthesia required more pain medication post-operatively than those receiving spinal anesthesia[16]. This, along with the fact that the literature seems to indicate a higher complication rate with general anesthesia when compared to spinal, suggests spinal anesthesia should be favored[17]. Both femoral nerve blocks and intrathecal morphine injections are inexpensive and safe procedures that will diminish pain in the post-operative period, and our study would indicate that using both of the these adjuncts to spinal anesthesia will provide the best post-operative pain control, or at the very least, diminished use of post-operative narcotics.

Limited studies examining the effect of gender on post-operative pain were available. Liu et al found female gender to be an independent risk factor for persistent pain after TKA but was more focused on long-term outcomes[18]. In our study, females reported significantly higher pain post-operatively when compared to males but did not consume greater amounts of pain medication. The fact that females did not consume more pain medication although it was available suggests that the post-operative pain medication protocol does not need to be adjusted, but patients should be encouraged to use the medication that is available to them if necessary.

No significant differences were noted between anesthesia groups with regards to postoperative pain or length of hospital stay. Patients receiving general anesthesia required significantly more daily IV morphine equivalents than patients receiving spinal anesthesia. On average, patients receiving both FNB and intrathecal morphine after spinal anesthesia consumed the least daily IV morphine equivalents, daily oral morphine equivalents, and daily average total morphine equivalents. In this study, patients receiving spinal anesthesia and femoral nerve block without intrathecal morphine had significantly shorter operative times compared with the other groups. One hypothesis is faster surgeons preferred this type of anesthesia and the average surgical time is therefore shorter. It is also possible that selection bias lead to more straightforward knees receiving this type of anesthesia, but it is beyond the scope and design of this study to accurately answer this question.

There are limitations with this study that must be considered. There were 14 surgeons included in the study. Subtle differences in technique could affect pain post-operatively and this would not be accounted for in this study. We searched for patients using a CPT code, but not all primary total knee arthroplasties are the same. We did not control for level of pre-operative pain or deformity. Furthermore, anesthesia type was not randomly assigned, leaving the present study open to selection bias based on anesthesia type. Also, patients received different pain medications post-operatively. Calculation of morphine equivalents will minimize the negative impact of this, but it must be considered.

CONCLUSION

In conclusion, our study supports the use of spinal anesthesia with both FNB and intrathecal morphine as the anesthesia regimen most effective in minimizing post-operative narcotic use. Length of stay and pain scores were not different among anesthesia groups. General anesthesia should be used only when spinal anesthesia is contraindicated. Females reported higher pain in the immediate post-operative period but did not use more morphine equivalents.

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