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The Efficacy of Regional Anesthesia Techniques to Control Postoperative Pain After Total Knee Arthroplasty

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BACKGROUND: Choosing the most effective type of anesthesia for controlling postoperative pain is paramount for improving patient outcomes and patient satisfaction. Most often, the type of anesthesia selected is dependent on the duration and type of surgical procedure and anesthesiologist/surgeon preference. Using a combination of regional anesthesia techniques, however, remains the cornerstone of multimodal analgesia for postoperative pain management after total knee arthroplasty.

PURPOSE: The purpose of this study was to determine what regional anesthesia techniques and/or combinations of regional anesthesia techniques provided the best postoperative pain control in patients who had undergone a total knee arthroplasty.

METHODS: Retrospective chart review.

RESULTS: Patients who received a single-shot regional anesthetic reported significantly more postoperative opiate consumption and requested pain medication significantly sooner than patients who received multimodal techniques of regional analgesia.

CONCLUSION: This study found support for the use of multimodal analgesia techniques for optimum postoperative pain management after total knee arthroplasty.

Total knee arthroplasty (TKA) is a surgical procedure that is associated with significant postoperative pain that, when inadequately controlled, can impair or even prevent early ambulation. The purpose of a TKA is to surgically replace diseased ends of the femur and the tibia with metal and plastic components to decrease pain and improve mobility. Therefore, a major short-term goal after a TKA is to control postoperative pain to obtain optimal range of motion for early ambulation. Early ambulation has been found to significantly improve long-term TKA outcomes by enhancing knee function and mobility. In addition, patients report higher satisfaction scores when postoperative pain is adequately controlled, which, in turn, may influence the patient's choice of provider, healthcare facility, and willingness to return for further care (Parvizi, Miller, & Gandhi, 2011). Hence, choosing the most effective type of anesthesia for controlling TKA postoperative pain is paramount for improving patient outcomes and patient satisfaction. Most often, however, the type of anesthesia selected is dependent on the surgical procedure, the duration of the surgical procedure, anesthesiologist and surgeon's preference, and, when possible, the patient's preference (Miller, 2015).

A major type of anesthesia used in TKA cases is regional anesthesia. The purpose of regional anesthesia is to temporarily disrupt sensory and motor impulses to and from a specific region of the body with no loss of consciousness (American Society of Regional Anesthesia and Pain Medicine, 2017). Bauer, Pogatzki-Zahn, and Zahn (2014) have reported that regional anesthesia techniques (topical, local infiltration [LI], peripheral nerve block, intravenous block, spinal, and epidural anesthesia) remain the cornerstone of multimodal analgesia for postoperative pain management. Yet, research evidence is limited regarding what regional anesthesia techniques to use for the best postoperative pain management after TKA. Thus, the purpose of this retrospective study was to determine what regional anesthesia techniques and/or combinations of regional anesthesia techniques provided the best postoperative pain control in patients who had undergone a TKA.

Specifically, the study compared

1. local infiltration;
2. single-shot peripheral nerve block (femoral or adductor canal);
3. single-shot peripheral nerve block and LI;
4. peripheral nerve block with a perineural catheter; and
5. peripheral nerve block with a perineural catheter and LI.

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Review of the Literature

Local Infiltration

One regional anesthesia technique used for postoperative pain management is LI of an anesthetic at the surgical site. In a prospective, randomized, controlled, double-blind study, Milani et al. (2015) found that 30 patients who had undergone a TKA with multimodal analgesia protocol and 32 patients who had undergone a TKA with multimodal analgesia and LI did not show statistical differences in postoperative pain reduction and range of motion. Conversely, Teng et al. (2014) conducted a meta-analysis based on randomized controlled trials that evaluated the efficiency of multimodal analgesia versus multimodal analgesia with LI in TKA. Teng et al. concluded that the multimodal analgesia and LI group had significantly lower pain scores on the surgical day and 1 day postoperative and the number of patients able to do active straight leg raise was significantly larger than the multimodal analgesia group. Similarly, in a prospective double-blind study of 35 patients who had undergone a medial opening-wedge high tibial osteotomy, Jung et al. (2014) reported that the use of LI anesthesia significantly reduced postoperative pain at 6 hours and 2-week postoperative period.

Peripheral Nerve Blocks

Another regional anesthesia technique for postoperative pain management is the peripheral nerve block. Peripheral nerve blocks may be used as a continuous infusion or a single injection of a local anesthetic around a nerve or a group of nerves causing temporary loss of sensory and motor function. One type of peripheral nerve block is a femoral nerve block, which has been used for postoperative pain management after a TKA (Bauer et al., 2014; Jaeger et al., 2013a); however, the blockade of the femoral nerve can cause short-term quadriceps muscle weakness (Jaeger et al., 2013a; Kim et al., 2014).

Quadriceps muscle weakness after a femoral nerve block is an undesirable effect in the immediate postoperative period because early mobilization after a TKA is essential to enhance functional recovery and reduce immobility-related complications, such as venous thrombosis. Weakness occurs in the quadriceps muscles because the femoral nerve supplies the motor innervation of the anterior thigh muscles (Agur & Dalley, 2005). In a retrospective study conducted by Luo, Ashraf, Dahm, Stuart, and McIntosh (2015), the use of femoral nerve blocks was reported to be strongly associated with decreased quadriceps and hamstring strength at 6-month follow-up appointments in 124 pediatric and adolescent patients who had undergone anterior cruciate ligament reconstruction. Pelt, Anderson, Anderson, Dine, and Peters (2014) also performed a retrospective review of 707 medical charts of patients who had undergone primary TKA with the use of a femoral nerve catheter and reported that 19 out of the 707 (2.7%) patients had experienced a postoperative inpatient fall. Finally, in a prospective double-blinded, randomized controlled trial that compared the use of an adductor canal block (ACB) with the use of a femoral nerve block in patients undergoing a TKA, the ACB demonstrated significant sparing of the quadriceps strength and was equivalent to the femoral nerve block regarding pain scores and postoperative opioid consumption (Kim et al., 2014).

The use of a pure sensory nerve block, however, has been reported to be an ideal part of postoperative pain management because a sensory nerve block eliminates the undesirable effects associated with a motor blockade. The ACB is an almost pure sensory block that anesthetizes the major sensory nerves of the knee: (saphenous nerve, posterior branch of the obturator nerve, and, in some case, the medial cutaneous nerve and the anterior branch of the obturator nerve [Jenstrup et al., 2012]). Findings from Grevstad, Mathiesen, Lind, and Dahl (2014) randomized, double-blind, placebo-controlled study determined that ACBs are an acceptable pain management modality when treating patients who are suffering with postoperative TKA movement-related pain. In a double-blind, randomized, controlled study, Jaeger et al. (2013b) found that there were no significant differences in pain scores or morphine consumption with the use of adductor canal or femoral nerve blocks in 48 patients who had undergone a TKA. Conversely, Memtsoudis et al. (2015) compared the effects of a single-shot ACB versus the use of femoral nerve blocks on patients undergoing TKA and found that patients reported better pain control with the femoral nerve block.

Disparity among these studies suggests that further research is needed to explore the efficacy of various modalities of regional anesthesia used among patients undergoing TKA. Research evidenced across studies suggests that the efficacy of local anesthesia and peripheral nerve blocks has advantages and/or disadvantages, yet it is still unclear which approach provides the best postoperative pain management among patients undergoing a TKA.

Method Section

A retrospective research design was used in this study to determine whether there were any differences between regional anesthesia techniques and/or combinations of regional anesthesia techniques and analgesic request for postoperative pain in patients who had undergone a TKA.

Operational definitions of the regional anesthesia techniques for this study were as follows:

1. Adductor canal block was produced by the administration of a single shot of a local anesthetic at the adductor canal.
2. Femoral nerve block was produced by the administration of a single shot of a local anesthetic around the femoral nerve.
3. Local infiltration was the injection of a local anesthetic, epinephrine, nonsteroidal anti-inflammatory drug, and opioid into surrounding soft knee tissue.
4. Perineural catheter was the insertion of a catheter placed at the adductor canal to allow for continuous infusion of a local anesthetic.

5. Postoperative breakthrough pain was determined by the documentation of the administration of "as needed" analgesic at the patient's request.

The null hypothesis for this retrospective study was as follows:

1. There will be no differences in analgesic requests for postoperative pain, and the time-in-minutes to the first requested analgesic given during the first three postoperative days among patients who have undergone TKA and received: (a) LI, (b) single-shot peripheral nerve block, (c) single-shot peripheral nerve block and LI, (d) peripheral nerve block with perineural catheter, and (e) peripheral nerve block with a perineural catheter and LI.

Setting and Sample

Written and/or electronic medical records were reviewed for this study from an orthopaedic unit within one hospital in the Midwest. The sample included patients who had underwent a TKA and had regional anesthesia that included LI, single-shot peripheral nerve block, single-shot peripheral nerve block and LI, peripheral nerve block with a perineural catheter, or a peripheral nerve block with a perineural catheter and LI from January 1, 2010, through December 31, 2015. Patient records were excluded from this study if the patient had (1) a TKA revision, (2) a unicompartmental knee arthroplasty, or (3) general anesthesia.

Procedures

Institutional review board and site approval from the same orthopaedic hospital in the Midwest was obtained prior to the initiation of this study. Modification of a published tool for transcribing data was used in this study for data collection purposes (Otten & Dunn, 2011). Data collected on this tool included (a) demographics, (b) type of regional anesthetic given, (c) length of stay, (d) minutes to the first postoperative requested analgesic administration, and (e) type of analgesic medications. Analgesic medications that were used included (1) extended release oxycodone and morphine sulfate, (2) pregabalin, (3) celecoxib, (4) tramadol, (5) acetaminophen, (6) ketorolac, (7) hydrocodone, (8) hydromorphone, and (9) morphine sulfate. The number of administered postoperative analgesics were then summed to compute a total number of postoperative analgesics given over 3 days. Data were analyzed using SPSS version 24 software. Frequencies, percentages, and independent-samples *t* test were computed. The level of significance was preset at .05.

Table 1. Description of the Sample (N = 110)

Variable	*n* (%)	Mean	*SD*	Range
Gender				
Male	43 (39.1)			
Female	66 (60.0)			
Age, years				
40–49	8 (7.3)			
50–59	33 (30.0)			
60–69	43 (39.1)			
70–79	17 (15.5)			
80–89	8 (7.3)			
90–99	1 (0.9)			
Length of stay		2.94	1.07	1–8
Minutes to first analgesic		720.03	949.04	4–4440
Total number of analgesics given		6.27	4.91	0–22

Results

Participants

One hundred ten patients met the criteria for inclusion in this study. Most participants were female (n = 66, 60.4%) and had ages ranging between 60 and 69 years (n = 43, 39.1%). On average, patients' length of stay was approximately 3 days (range = 1–8), minutes to the first analgesic request was 720.03 minutes (*SD* = 949.03, range = 4–4,440), and total number of analgesics given was 6.27 (*SD* = 4.91, range = 0–22; see Table 1). Majority of regional anesthesia types were LI (n = 34, 30.9%), followed by femoral nerve block (FNB; n = 28, 25.5%) and ACB with perineal catheter (n = 17, 15.5%; see Table 2). Only one case using a popliteal nerve block with LI was found within the proposed study period and therefore was not included in the data analyses.

Minutes to First Analgesic Request Between Regional Anesthesia Types

The shortest average time-in-minutes to the first postoperative requested analgesic between the different regional anesthetics was FNB (M = 268.04, *SD* = 245.26, range = 5–1,050), followed by ACB (M = 445.75, *SD* = 659.12, range = 49–1,430). The longest average time-in-minutes to the first postoperative requested analgesic between the different regional anesthetics was FNB with LI (M = 1,800.17, *SD* = 1,707.82, range = 7–4,440), followed by ACB with perineural catheter and LI (M = 1,597.50, *SD* = 931.21, range = 8–2,880; see Table 2).

Statistically significant differences between the different regional anesthetics techniques and time-in-minutes to the first postoperative requested analgesic were found between FNB and ACB with LI ($t_{38} = -2.353$, $p < .05$), FNB and ACB with perineural catheter ($t_{43} = -2.315$, $p < .05$), and LI and FNB ($t_{60} = 2.430$, $p < .05$; see Table 3). Patients who had received FNBs requested their first postoperative analgesic significantly earlier than patients who had received ACB with LI, patients who had received ACB with perineural catheter, and patients who had received LI after undergoing a TKA.

Total Analgesics Requested Postoperatively Between Regional Anesthesia Types

The lowest average total number of analgesics requested during the first three postoperative days after undergoing a TKA procedure was with ACB with perineural

Table 2. Types of Regional Anesthesia, Minutes to First Postoperative Analgesic Administration, and Total Number of Postoperative Analgesics Given (N = 110)

Regional Anesthesia	*n* (%)	Mean	*SD*	Range
Local infiltration (LI)	34 (30.9)			
Minutes to First Analgesic		679.62	866.80	4–3523
Total number of analgesics given		4.94	4.18	0–17
Adductor canal block (ACB)	4 (3.6)			
Minutes to First Analgesic		445.75	659.13	49–1430
Total number of analgesics given		10.25	2.22	7–12
Femoral nerve block (FNB)	28 (25.5)			
Minutes to first analgesic		268.04	245.63	5–1050
Total number of analgesics given		9.07	5.28	1–22
ACB with LI	12 (10.9)			
Minutes to first analgesic		831.92	1232.44	38–4320
Total number of Analgesics given		6.83	4.11	0–12
FNB with LI	6 (5.5)			
Minutes to first analgesic		1800.17	1707.82	7–4440
Total number of analgesics given		4.50	4.50	0–13
ACB with perineural catheter	17 (15.5)			
Minutes to first analgesic		679.12	891.32	11–2924
Total number of analgesics given		5.24	4.29	1–14
ACB with perineural catheter and LI	8 (7.3)			
Minutes to first analgesic		1597.5	931.22	8–2880
Total number of analgesics given		3.38	5.76	0–17

catheter and LI (M = 3.38, SD = 5.75, range = 0–17), followed by FNB with LI (M = 4.50, SD = 4.50, range = 0–17). The highest average total number of analgesics requested during the first three postoperative days after undergoing a TKA was with ACB (M = 10.25, SD = 2.21, range = 7–12), followed by FNB (M = 9.07, SD = 5.27, range = 0–17; see Table 2).

Statistically significant differences between the regional anesthetics and total number of analgesics requested during the first three postoperative days after undergoing a TKA were found between FNB and ACB with LI (t_{43}= 2.529, $p < .05$) and LI and FNB (t_{60}= −3.438, $p < .05$; see Table 3). Patients who had received FNBs requested significantly more analgesics during the first three postoperative days than patients who had received ACB with perineural catheter and patients who had received LI after undergoing a TKA.

Discussion

Retrospective review of the medical records of patients who had undergone a TKA from January 1, 2010, through December 31, 2015, in one hospital revealed very interesting findings regarding the effectiveness of the regional anesthetic techniques used in each case. Findings from this study suggested that patients who received a single-shot FNB requested pain medications significantly sooner than patients who received multimodal analgesia—ACB with LI and ACB with perineural catheter. Results of this study are consistent with the studies by Jaeger et al. (2013b) and Kim et al. (2014) that found no statistically significant difference in postoperative pain management in patients who have undergone a TKA and received either an adductor or femoral nerve block. This study, however, found that adding another regional anesthetic technique (LI and perineural catheter) with the ACB did statistically increase the time-in-minutes to the first requested analgesic requested by the patients, suggesting better postoperative pain management.

Similarly, a statistically significant difference in the average time-in-minutes to the first postoperative requested analgesic was also found between FNB and intraoperative LI into the surrounding soft tissues of the knee. Patients who had an FNB requested an analgesic much sooner than those who had LI. This finding is not consistent with a meta-analysis conducted by Wang, Cai, and Yan (2015), who found that patients who had undergone a TKA with FNB reported statistically lower ratings on visual analogue scales 12 hours postoperative than those patients who had undergone a TKA with LI. When evaluated at 24 hours postoperative for pain, however, patients who had LI reported less pain than those who had FNB, suggesting that the analgesic efficacy of a single-shot LI may last longer than a single-shot FNB.

Patients who had femoral nerve blocks were also found to request statistically more postoperative analgesics than patients who had ACB with LI and patients who had LI. These findings support Ashraf, Raut, Canty,

Table 3. Independent-Samples *T*-Tests of Significance Between Types of Regional Anesthesia, Minutes to First Analgesic, and Total Number of Analgesic Given (*N* = 110)

Regional Anesthesia	*T*	*df*	Level of Significance
Local infiltration (LI) and adductor canal block (ACB)			
Minutes to first analgesic	0.520	36	.61
Total number of analgesics given	−2.475	36	.02[a]
Femoral nerve block (FNB) and ACB with LI			
Minutes to first analgesic	−2.353	38	.02[a]
Total number of analgesics given	1.306	38	.20
FNB and ACB with perineural catheter			
Minutes to first analgesic	−2.315	43	.02[a]
Total number of analgesics given	2.529	43	.02[a]
LI and ACB with perineural catheter			
Minutes to first analgesic	0.002	49	.99
Total number of analgesics given	−0.235	49	.82
ACB with LI and ACB with perineural catheter			
Minutes to first analgesic	0.388	27	.70
Total number of analgesics given	1.004	27	.32
ACB with LI and ACB with perineural catheter with LI			
Minutes to first analgesic	−1.491	18	.15
Total number of analgesics given	1.573	18	.13
FNB with LI and ACB with perineural catheter with LI			
Minutes to first analgesic	0.286	12	.78
Total number of analgesics given	0.395	12	.70
LI and FNB			
Minutes to first analgesic	2.430	60	.01[a]
Total number of analgesics given	−3.438	60	.00[a]

[a]The level of significance was preset at .05; two-tailed level of significance.

and McLauchlan's (2013) study that found that in a randomized sample of 40 patients who had undergone TKA, intraoperative LI provided statistically better pain relief and less opiate usage within the first 24 hours of the postoperative period than FNB. A meta-analysis conducted by Wang et al. (2017) also found that there was no significant difference between the pain ratings and opiate consumption post-TKA between ACB and FNB. This study, however, found that adding LI with the ACB did significantly decrease opiate consumption compared with FNB within 3 days postoperative TKA, suggesting that this multimodal regional technique provides better pain management than single-shot FNB.

Limitations

Several of the study's limitations warrant consideration. One such limitation is that within the study period, there were more TKAs using intraoperative LI of a local anesthetic into the soft tissues of the knee than the other four anesthetic groups, thus decreasing homogeneity of the sample. Second, the sample consisted predominately of females, which may limit its generalizability to the male population. A third limitation of the study may have been related to the nurses' personal biases and knowledge of acute pain, which may cause discrepancies in pain perceptions and breakthrough pain management. The patient's past or current use of opioids may also have caused variance in pain perceptions and pain management. Finally, because this was a retrospective chart review, the dosages of peripheral nerve blocks were not consistent. However, one may assume that these dosages were based on the perioperative evaluations done with each patient.

Conclusion

The concept of multimodal analgesia was introduced more than a decade ago to control postoperative breakthrough pain with less reliance on opioids (Parvizi, Miller, & Gandhi, 2011). This retrospective study highlighted that patients who received a single-shot regional anesthetic reported significantly more opiate consumption for breakthrough pain and requested pain medication significantly sooner than patients who received a multimodal type of regional analgesia. Therefore, it is essential that the surgeon and the anesthesiologist choose the most effective multimodal pain regimen that would provide optimal postoperative pain control for patients who are undergoing a TKA. Similarly, it is also important for patients and their families to be educated on the benefits and risks of multimodal pain management versus using only single-shot regional anesthesia.

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