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Comparison between periarticular injection and intraarticular infusion for pain control following total knee arthroplasty

Mutlu Akdoğan[1], İlkay Baran Akkuş[2], Halis Atıl Atilla[1], Alper Öztürk[1], Yenel Gürkan Bilgetekin[1], Önder Ersan[1]

[1]Department of Orthopaedics and Traumatology, University of Health Sciences, Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey
[2]Department of Anesthesiology, University of Health Sciences, Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey

ABSTRACT

Objectives: To compare periarticular infiltration and intraarticular continuous infusion methods in pain management following total knee arthroplasty (TKA).

Methods: Patients who underwent TKA from May 2015 through September 2015 according to their postoperative pain protocol were compared. The patients who received bupivacaine by periarticular infiltration (PAI group) and intraarticular infusion (IAI group) were included in the study. Patients also received a treatment through intravenous patient-controlled analgesia (PCA) device. The frequency of patients' bolus need and the tramadol dose used via PCA device, Visual Analogue Scale (VAS) scores and clinical evaluation as active knee flexion at the postoperative 3th day were obtained from the patient follow - up forms and records. Side effects related to narcotic analgesic medications were also obtained.

Results: The study included 90 patients, of whom 46 were in the PAI group (median age, 65.5 years; females, 82.6%) and 44 were in the IAI group (median age: 65.5 years; females, 81.8%). The VAS pain scores assessed at various postoperative time points and tramadol consumption were usually lower in the IAI group than in the PAI group. No difference was determined between the groups regarding the 3th-day VAS scores in flexion and in terms of analgesia-associated side effects.

Conclusions: Bupivacaine administration by IAI for postoperative pain management following TKA is associated with lower pain and lower tramadol consumption as compared with bupivacaine administration by PAI. The groups were comparable in terms of side effects. Accordingly, IAI seems to be an effective and safe analgesic technique for patients undergoing TKA.

Keywords: Arthroplasty, replacement, knee, pain, postoperative, infusion pumps, analgesia, patient-controlled

Postoperative pain is one of the important problems in modern medicine. Severity of pain may sometimes outweigh the success of surgery; in fact, surgery becomes questionable from the patient's point of view. Therefore, postoperative pain management has currently become one of the critical components of the patient care [1]. Effective pain management not only provides patients with comfort and satisfaction but also enables early mobilization, lower pulmonary and cardiac complications, reduced risk of deep vein thrombosis, and faster recovery and thereby results in decreased cost of care [2].

Total knee arthroplasty (TKA) is one of the most frequently performed surgical procedure in orthopedic

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Address for correspondence: *Alper Öztürk, MD., University of Health Sciences, Dışkapı Yıldırım Beyazıt Training and Research Hospital, Department of Orthopaedics and Traumatology, Şehit Ömer Halisdemir Cad. No: 20, Altındağ, Ankara, Turkey. E-mail: dr_alperozturk@yahoo.com*

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surgery and annual number of this procedure is increasing gradually worldwide due to prolonged life expectancy [3]. Complaint of pain is frequent after TKA and causes significant problems concerning both postoperative rehabilitation and patient comfort [4]. New methods such as peripheral nerve blocks, periarticular injections, intravenous or epidural patient-controlled analgesia (PCA), and intraarticular continuous infusion pumps have been implemented to provide an effective analgesia after TKA [4, 5].

Periarticular infiltration and intraarticular continuous infusion pumps are the locally effective methods that are frequently preferred for pain management following TKA [6-9]. The present study aimed to compare these two local effective methods 'periarticular infiltration and intraarticular continuous infusion methods' in pain management following TKA.

METHODS

A prospective controlled study was conducted in patients with severe knee osteoarthritis scheduled for TKA surgery. Two groups were constituted regarding the two different post-operative pain management preference of the two senior surgeons as; periarticular infiltration (PAI) and intraarticular continuous infusion (IAI). After the approval of the local ethics committee, consecutive patients who had gonarthrosis were enrolled in the study. Informed constents of the patients was obtained from all patients. Patients were excluded if; the ASA (American Society of Anesthesiologists) score was IV or more, patients had previously diagnosed inflammatory arthritis, patients had severe knee deformity, there was a previous knee surgery, patients had an advanced liver or kidney disorders, patients had neuropathic pain, psychiatric disorders and documented allergy against local anesthetics.

Spinal anesthesia through administration of 15 mg hyperbaric bupivacaine (0.5%) at the L2-3 or L3-4 level was performed in all patients routinely by the same anesthesia team. The patients were placed in the supine position after anesthesia. The surgical procedure was started when the spinal block reached to the level of T8-10. Thigh tourniquet was applied for all patients; however, it was inflated only during bone cement application. Fixed-bearing, cruciate-retaining cemented total knee prostheses (Zimmer Warsaw, IL, USA) were implanted for all patients included in the study. The native patella was retained in all patients.

The patients who had periarticular infiltration (PAI) as postoperative analgesia assigned as group PAI and those who had intraarticular infusion (IAI) for postoperative analgesia assigned as group IAI. In the PAI group, a 60-mL solution composed of 40 mL of 0.5% bupivacaine and 20 mL of saline was infiltrated into the posterior capsule and medial and lateral collateral ligaments prior to the implantation and into the patellar tendon, fascia and subcutaneous tissue along the incision after the implantation. In the IAI group, ON-Q elastomeric infusion pumps (I-Flow LLC/Kimberly Clark) Hopkins, Flrd, USA) catheter was placed into the joint along the lateral margin. A solution composed of 200 mL 0.5% bupivacaine and 100 mL saline was prepared; 40 mL of this solution was infused as bolus into the joint without deflating the tourniquet. Infusion pump clamp was opened and infusion continued for 48 hours at a rate of 5 mL/h. A hemovac drain was not placed in any of the patients. The tourniquets were deflated in all patients after applying a compressive Jones bandage. The bandages were removed after 24 hours of surgery and the patients were allowed assisted walking and to perform active and passive movements.

In addition to the above-mentioned pain management methods, the study groups also received a treatment through intravenous (IV) PCA device; the treatment was the same for both groups. PCA device is a patient-controlled device which allows the patient to receive additional analgesic at a time determined by him/her and with the maximum dose limited by the device. Using a PCA device (Abbott Laboratories, Chicago, IL, USA), a 48-hour IV tramadol infusion was performed at a rate of 5 mg/h with a bolus dose of 10 mg and with a lockout time of 20 minutes. The frequency of patients' bolus need and the total amount of tramadol used via PCA device were recorded. For nausea and vomiting, IV metoclopramide (20 mg) was administered maximum three times a day. The patient records were assessed for any sign of side effects related to narcotic analgesic medications and the findings were recorded.

The cost of the pain management methods was measured as the cost of infusion pump and total used medications for IAI group and the cost of medications

used for PAI group.

All the patients who underwent surgery were informed about the horizontal Visual Analogue Scale (VAS; 0: No pain, 100: Unbearable pain) that was used for pain assessment. Resting VAS scores were recorded at 4-hour intervals in the first 24 h after the surgery and then on the 2nd and 3th days. The patients were allowed to exercise after the removal of Jones bandage at the 24th hour; VAS scores during exercise were recorded at on the 2nd and 3th days.. The patients were clinically evaluated based on their degree of active knee flexion on the postoperative 3th day.

Statistical Analysis

Data analysis was performed by the Predictive Analytics Software (PASW) 18.0 (SPSS Inc., Chicago, IL, USA) for Windows program. Descriptive statistics were expressed as number and percentage for categorical variables and as mean, standard deviation, median, and quartiles Q1 (25th percentile) and Q3 (75th percentile) for numerical variables. Comparison of two groups for categorical variables was performed using chi-square analysis, and when chi-square condition was not met, Fischer's exact test was performed. Comparison of two groups for non-normally distributed numerical variables was performed by Mann-Whitney U test. The level of statistical significance was accepted as $p < 0.05$.

RESULTS

A total of 112 consecutive patients, operated on from May 2015 through September 2015 by two experienced surgeons were included in the study. 22 patients were excluded from the study for several reasons (6 for having previous knee surgery, 6 for having ASA score of 4 or more, 1 for having neuropathic pain, 1 for not co-operating regarding the use of PCA device, 1 for having chronic liver-kidney disorder, 2 for having early postoperative infection, 4 for technique problems about the infusion device and 1 for having psychiatric disorder). Finally there were 90 patients (46 in PAI group and 44 in IAI group) in the study. The study groups were comparable in terms of age and gender (Table 1).

The VAS scores of the patients are summarized in Table 2. While the median resting VAS scores at the 4th hour and on the 3th day were significantly lower in the PAI group ($p = 0.001$ and $p < 0.001$, respectively), the median resting VAS scores were significantly lower at the 8th, 12th, 16th, 20th and 24th hours in the IAI group ($p < 0.001$ at all). The median VAS scores during exercise at the 24th hour and on the 3th day were significantly lower in the IAI group ($p < 0.001$ and p < 0.001, respectively). No difference was determined between the groups in terms of the 3th-day VAS scores in flexion ($p = 0.102$).

Comparison of the PCA use between the groups revealed that the median tramadol dose used within 0-6 hours was lower in the PAI group, whereas the median total tramadol dose was lower in the IAI group (Table 3). The cost of pain management protocols were approximately 265€ for patients in IAI group and 10€ for patients in PAI group.

The most common analgesia-associated side effect was nausea followed by headache and constipation. The distribution of side effects in the PAI and IAI groups is demonstrated in Table 4. No significant difference was observed between the two groups in terms of the distribution of side effects.

Table 1. Demographic characteristics of the patients

	Group PAI (n = 46)	Group IAI (n = 44)	*p* value
Age, Median (Q1-Q3)	65.5 (62-69)	65.5 (62-69)	0.903[a]
Gender, n (%)			
Female	38 (82.6)	36 (81.8)	0.922[b]
Male	8 (17.4)	8 (18.2)	

PAI = periarticular infiltration, IAI = intraarticular infusion, Q1 = the 1st quartile, Q3 = the 3rd quartile
[a]Mann-Whitney U test, [b]Chi-square test

Table 2. Visual analog scale pain scores

	Group PAI (n = 46)	Group IAI (n = 44)	*p* value*
Resting VAS scores	Median (Q1-Q3)	Median (Q1-Q3)	
4th hour	10 (10-10)	10 (10-20)	**0.001**
8th hour	30 (30-40)	20 (20-20)	**< 0.001**
12th hour	40 (40-40)	30 (30-30)	**< 0.001**
16th hour	40 (40-40)	20 (20-30)	**< 0.001**
20th hour	40 (40-40)	30 (30-30)	**< 0.001**
24th hour	40 (40-40)	30 (30-35)	**< 0.001**
2nd day	30 (30-30)	30 (30-30)	0.068
3th day	30 (30-40)	40 (40-40)	**< 0.001**
VAS scores during exercise			
24th hour	55 (50-60)	50 (40-50)	**< 0.001**
2nd day	55 (50-60)	50 (40-50)	**< 0.001**
3th day	40 (40-50)	40 (40-40)	0.055
3th-day VAS score in flexion	85 (85-90)	90 (85-95)	0.102

PAI = periarticular infiltration, IAI = intraarticular infusion, VAS = Visual analog scale, Q1 = the 1st quartile, Q3 = the 3rd quartile

*Mann-Whitney U test

Table 3. Amount of tramadol used via patient-controlled analgesia device

	Group PAI (n = 46)	Group IAI (n = 44)	*p* value*
Tramadol use	Median (Q1-Q3)	Median (Q1-Q3)	
0-6 hours, mg	30 (30-35)	35 (35-40)	**< 0.001**
Total, mg	400 (380-420)	360 (350-370)	**< 0.001**

PAI = periarticular infiltration, IAI = intraarticular infusion, VAS = Visual analog scale, Q1 = the 1st quartile, Q3 = the 3rd quartile

*Mann-Whitney U test

DISCUSSION

Perioperative pain management in patients undergoing TKA remains to be one of the most challenging issues for both the surgeons and the anesthesiologists. Reducing pain is the essential component of patient satisfaction, functional outcomes, and duration of hospital stay [10]. In addition to the changes and evolutions in the surgical techniques, anesthesia and analgesia techniques have also evolved over time. Regional anesthesia techniques have replaced the general anesthesia [11]. This also applies to the postoperative pain management; local implementations are gradually becoming more popular as the traditional opioid-based methods are associated with numerous side effects [12]. Kerr and Kohan [13] defined local infiltration analgesia (LIA) as a simple, practical, safe and effective method and stated that it targets to achieve satisfactory pain management with little physiological disturbance. Gibbs *et al*. [14] conducted a review including 29 randomized trials and concluded that LIA following TKA was successful in postoperative pain management. It has been reported that continuous LIA is superior to placebo in relieving pain but that it might be associated with increased risk of infection. Nevertheless, continuous LIA has not

Table 4. Analgesia-associated side effects

	Group PAI (n = 46)	Group IAI (n = 44)	*p* value
Nausea, n (%)	11 (23.9)	9 (20.5)	0.693[a]
Headache, n (%)	8 (17.4)	6 (13.6)	0.623[a]
Constipation, n (%)	8 (17.4)	5 (11.4)	0.416[a]
Pruritus, n (%)	7 (15.2)	5 (11.4)	0.591[a]
Vomiting, n (%)	6 (13.0)	5 (11.4)	0.808[a]
Dry mouth, n (%)	6 (13.0)	5 (11.4)	0.808[a]
Urine retention, n (%)	6 (13.0)	4 (9.1)	0.740[b]
Dizziness, n (%)	6 (13.0)	4 (9.1)	0.551[b]
Sleepiness, n (%)	6 (13.0)	3 (6.8)	0.486[b]

PAI = periarticular infiltration, IAI = intraarticular infusion, VAS = Visual analog scale
[a]Chi-square, [b]Fisher's exact test

been found to be associated with prolonged surgical duration or prolonged length of hospital stay [15]. Moreover, LIA results in low hospital cost as compared with the standard analgesia [16].

During local interventions, various agents in different combinations and at different doses are infiltrated into the periarticular tissue or injected or infused into the intraarticular space via catheters during surgery and/or after surgery [14]. It is not apparent from which tissue the pain following TKA primarily arise; additionally, which one of the methods used for pain management is the most optimal is also controversial. Karlsen *et al*. [17] conducted a systematic review to identify the most effective and safe method for postoperative pain management and included 113 eligible study identified by literature search; they concluded that it was difficult to determine the optimal therapeutic regimen because of small sample sizes, heterogeneous study designs, and low quality of evidence.

The PAI and IAI have been evaluated in clinical studies. The main finding of this study was the better pain management of IAI when compared to PAI with comparable side-effects of the drugs. Although these protocols are widely questioned in literature individually, there is not enough knowledge comparing these techniques in terms of pain management and side effects. PAI is widely studies by many authors and its favorable outcomes were reported. Chaumeron *et al*. [18] reported the PAI as effective as femoral nerve block and Kerr and Kohan [13] reported the reduced need for morphine with PAI. Mullaji *et al*. [19] studied the effectiveness of PAI in patients with bilateral TKA and demonstrated that patient felt less pain in their PAI side. Yuenyongviwat *et al*. [20] conducted a placebo-controlled study and administered bupivacaine by the PAI for postoperative pain control in patients undergoing TKA and demonstrated the decrease in morphine consumption in PAI group. The use of intraarticular agents for postoperative pain management has also been evaluated before. Browne *et al*. [21] reported lower pain and narcotic consumption in the patients receiving intraarticular bupivacaine injection than in those receiving placebo (saline), following capsule closure during TKA; however, they reported that the difference did not reach a statistical significance. Kazak *et al*. [22] reported that intraarticular bupivacaine administration was associated with better postoperative analgesia, lower tramadol consumption, and shorter hospital stay as compared with placebo administration. However there are limited studies aimed to compare these two protocols in patients undergoing TKA surgery. Perret *et al*. [23] compared the outcomes of PAI and IAI methods in patients undergoing TKA and reported no difference between groups regardin postoperative opioid consumption. As compared with the intraarticular group, the VAS scores on the postoperative 1st day and during hospital discharge were reported to be lower and the duration of hospital stay was reported to be longer in the peri-

articular group. Based on these results, Perret *et al*. [23] concluded that none of the methods was superior to another. But contrary to Perret *et al*. [23], this study demonstrated the better pain control of IAI day after surgery. Although PAI patients had better pain control at first hours of surgery which was probably caused from the higher amount of bupivacaine in the bolus doses, the IAI was superior for pain control when the postoperative days were considered. In addition, although patients in IAI groups received more bupivacaine through 3 days, the side effects of the groups were comparable.

Bupivacaine, with its proven efficacy, is one of the agents used frequently as a part of multimodal pain management in TKA [24]. In the present study, we also used bupivacaine for pain management following TKA and compared PAI and IAI methods. In the present study, the VAS pain scores assessed at various postoperative time points were usually lower in the IAI group than in the PAI group. The total amount of tramadol consumption was also lower in the IAI group. No difference was determined between the two groups in terms of analgesia-associated side effects. It has been reported that demographic characteristics such as age and gender are effective in postoperative pain following knee surgeries [25]. In the present study, the groups were comparable in terms of age and gender. This eliminated the effects of demographic characteristics on study outcomes. In the present study, surgical procedures were performed by two surgical teams which graduated from the same institution and performs the TKA in a very similar way on the other hand the same anesthesia team was on duty in all patients, which was also an advantage for making accurate evaluations. It has been reported that perioperative anesthesia and analgesia are effective also on the outcomes after one month of surgery [26].

Limitations

Lack of assessment of the long-term outcomes can be considered as a limitation of the present study.

CONCLUSION

In conclusion, bupivacaine administration by IAI for postoperative pain management following TKA is associated with lower pain and lower tramadol consumption as compared with bupivacaine administration by PAI. The groups were comparable in terms of side effects. Accordingly, IAI seems to be an effective and safe technique.

Authors' Contribution

MA = Study design; İBA = Performing anesthetical procedures and technical review; HAA = Patient admission, surgical team; AÖ = Critical review, technical revisions; YGB = Data collection, statistical work; and ÖE = Critical scientifically revision

Conflict of interest

The author disclosed no conflict of interest during the preparation or publication of this manuscript.

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