Additional pain relieving effect of intraoperative periarticular injections after simultaneous bilateral TKA: a randomized, controlled study

In Jun Koh · Yeon Gwi Kang · Chong Bum Chang · Sae Kwang Kwon · Eun Seok Seo · Sang Cheol Seong · Tae Kyun Kim

Abstract The authors investigated the clinical value of intraoperative periarticular multimodal drug injections (PMDI) in patients on continuous epidural analgesia after simultaneous bilateral TKAs. In 55 patients scheduled to undergo simultaneous bilateral TKAs, one knee was randomly assigned to the PMDI group for which intraoperative periarticular injections were administered and the other knee was assigned to the No-PMDI group for which the injections were not done. These two groups were compared for pain level (during the operation night and on postoperative days (POD) 1, 4, and 7), functional recovery (ability to perform straight leg raising on POD 1 and maximum flexion on POD 7), patient satisfaction (POD 7), and the incidence of wound complications. The PMDI group showed a lower pain level during the operation night and on POD 1 than the No-PMDI group, but no differences in pain levels were observed between the groups on POD 4 or 7. Furthermore, no significant group differences were found in terms of functional recovery, patient satisfaction. No wound complication has been occurred in the PMDI group. This study demonstrates that PMDI provides additional pain relief limited to the immediate postoperative period but does not improve pain relief after POD 1, patient satisfaction and functional recovery.

Keywords Total knee arthroplasty · Periarticular multimodal drug injection

Introduction

Despite improvements in analgesic modalities, a substantial proportion of TKA patients experience severe postoperative pain during the early recovery period [15, 24]. Furthermore, anticipated perioperative pain has been reported to be ranked high among concerns before TKA [17, 26]. No gold standard pain management protocol has been established, but the preemptive use of multimodal options is currently accepted as a principle of contemporary pain management [5, 15, 20, 32]. Recently, periarticular multimodal drug injection (PMDI) has been reported to provide remarkable pain relief and reduce opioid consumption [3, 13, 15, 18, 19, 23, 25, 27]. However, heterogeneities among studies regarding drug composition, infiltration techniques, concomitant pain management protocols, and outcome variables make it difficult to judge the practical value of PMDI in patients after TKA.

Simultaneous bilateral TKAs are not infrequently preformed, and more efficient pain control protocols may be necessary assuming that patients after bilateral TKAs experience more severe pain due to theoretically doubled surgical trauma [4, 14, 22, 33]. Continuous epidural analgesia using an indwelling epidural catheter following combined spinal epidural anesthesia can be a good option for simultaneous bilateral TKAs, because it provides extended anesthesia for bilateral operation and prolonged postoperative analgesia [2, 8, 12, 16, 28, 29, 31]. In theory,

I. J. Koh · Y. G. Kang · C. B. Chang · S. K. Kwon ·
E. S. Seo · T. K. Kim (✉)
Joint Reconstruction Center,
Department of Orthopaedic Surgery, Seoul National University
Bundang Hospital, 166 Gumi-ro, Bundang-gu, Seongnam-si,
Gyeonggi-do 463-707, Korea
e-mail: osktk@snubh.org

Y. G. Kang
Department of Statistics, Dankook University, Yongin, Korea

C. B. Chang · S. C. Seong · T. K. Kim
Department of Orthopaedic Surgery,
Seoul National University College of Medicine, Seoul, Korea

a combination of continuous epidural analgesia that blocks the transmission of afferent pain impulses at the spinal cord level and PMDI that blocks pain at surgical trauma sites can offer additive and synergistic pain relief effect. On the other hand, if the pain relief by continuous epidural analgesia was enough to obviate the need for additional pain control measures, there would be no need for the PMDI in patients received continuous epidural analgesia. However, no previous study has been conducted to investigate the clinical value of PMDI in patients on continuous epidural analgesia after simultaneous bilateral TKA.

Thus, this prospective randomized controlled study was performed to determine whether PMDI provides additional pain relief in patients on continuous epidural analgesia after simultaneous bilateral TKA. It was hypothesized that patients would experience less pain and faster recovery (as determined by straight leg raising and maximum flexion) in knees treated with PMDI and would be more satisfied with PMDI-treated knees.

Materials and methods

After obtaining approval from our institutional review board (B-0804/056-021), 71 patients scheduled for simultaneous bilateral TKAs provided informed consent to participate in this study. The inclusion criteria were a diagnosis of primary osteoarthritis, a mental ability to provide informed consent and co-operate. The exclusion criteria applied were failure of epidural anesthesia, discontinued epidural analgesia including dislodgement of the epidural catheter and intolerance or allergy to any of drugs used in this study. Of the 71 patients enrolled in this study, 5 patients were excluded: 4 because they could not complete questionnaire and 1 for a diagnosis other than osteoarthritis (rheumatoid arthritis; Fig. 1). Thus, 66 patients were recruited, and one knee was randomly assigned to the PMDI group, which received intraoperative periarticular injections, and the contralateral knee was assigned to the No-PMDI group, which did not receive the injections. Randomization was performed using a randomization table composed of permuted blocks of 4 and 6. The randomization table was created by a statistician who did not otherwise participate in this study; patients and the surgeon were unaware of block sizes. The patients and a clinical investigator (one of the authors), who prospectively collected all clinical information, were unaware of the randomization details until final data analysis. Eleven of the 66 patients were excluded for various reasons: 9 for epidural catheter dislodgement and 2 for general anesthesia due to unsuccessful epidural anesthesia. Consequently, 55 patients were included in the final analyses. There were 53 female and 2 male patients. The median age was 69 years ranging from 54 to 78. The median patient height, weight, and body
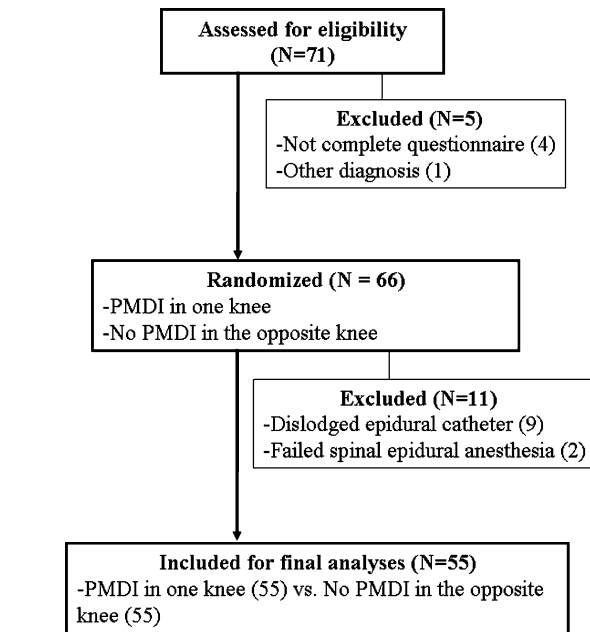

Fig. 1 Subject screening and enrollment flowchart

mass index (BMI) were 153 cm (range, 140–171) and 67 kg (range, 49–99), and 29 kg/m^2 (range, 22–37), respectively. There were no significant differences in preoperative flexion contracture and maximum flexion between the two groups ($P > 0.05$, Mann–Whitney U test). Final outcome adjudications were completed in April 2009.

All patients received the same perioperative management protocol. Briefly, oral analgesic drugs (Oxycodone SR 10 mg and Celebrex 200 mg) were administered for preemptive analgesia on a call basis before surgery. All patients received combined spinal-epidural anesthesia (10–15 mg of 0.5% Marcaine (bupivacaine) and 20 μg fentanyl) by an anesthesiologist. An epidural catheter was placed at the L3-4 level, and no anesthetic was injected through the catheter preoperatively. A Foley catheter was placed after anesthesia and removed on POD 2 or 3. Three hours after making the skin incision, or when a patient complained of pain, 10–15 ml of 0.75% ropivacaine was administrated via the epidural catheter as a bolus. After surgical procedures were completed, the epidural catheter was connected to a patient controlled epidural analgesia pump that was set to provide a continuous infusion of 500 μg fentanyl and 30 ml of 0.5% bupivacaine at a rate of 4 ml/h, with an on-demand bolus infusion of 2 ml with a 20-min lockout period. Ketorolac 30 mg was administered intravenously every 8 h for 3 days postoperatively. Once patients resumed oral intake, Celebrex 200 mg was administered every 12 h throughout the 9-day admission period and a Hycodone 1 tablet was administered every 6 h from POD 4–9. An intramuscular injection of ketoprofen (100 mg) was used as the first-line acute pain rescuer for

patients complaining of pain, and a subcutaneous injection of hydromorphone (1 mg) was used for the second line if pain relief by the ketoprofen injection was insufficient. Epidural analgesia was typically discontinued on POD 3 or before if the epidural PCA pump had been emptied. All patients were given thromboprophylaxis as recommended by the American Association of Orthopaedic Surgeons' Clinical Guideline on the prevention of symptomatic pulmonary embolism [7].

All surgical procedures were performed by a single surgeon (one of the authors) using a standard medial patellar arthrotomy technique with a tourniquet, and a standard postoperative rehabilitation protocol was adopted. Single posteriorly stabilized prostheses (Genesis II; Smith and Nephew, Memphis) were implanted in all cases. The patella was resurfaced in all knees, and cement fixation was used for all components. A compressive dressing was applied with an immobilizer during the first 24 h after surgery. Patients were encouraged to perform quadriceps-strengthening exercise after they had returned to the ward. All patients were allowed to walk as tolerated using a walker or crutches on POD 1. Knees were placed in a continuous-passive-motion (CPM) machine twice a day from POD 2 until discharge. All patients were discharged on POD 9.

Periarticular multimodal drug injections (PMDI) administration was carried out in an identical manner in all 55 patients. A 100-ml PMDI cocktail (300 mg of ropivacaine (40 ml), 10 mg of morphine sulfate (10 ml), 30 mg of ketorolac (troloc; 1 ml), 300 µg of 1: 1,000 epinephrine (0.3 ml), 750 mg of cefuroxime (10 ml), and normal saline (38.7 ml)) were prepared in two 50-ml syringes. After prostheses had been fixed with cement, 20 ml of the PMDI cocktail in the first syringe was injected into the sheath of the medial and lateral collateral ligaments and posterior capsule before polyethylene insert insertion. Before joint capsule closure, the remaining 30 ml of the PMDI cocktail was injected into synovium, capsule, and quadriceps muscle. After joint capsule closure, 50 ml of the PMDI cocktail in the second syringe was infiltrated into subcutaneous tissue, the capsule, and the quadriceps muscle.

A clinical investigator (one of the authors) unaware of randomization details prospectively collected demographic data and preoperative clinical details using predesigned datasheets and entered them into a database. Preoperative clinical statuses were evaluated using knee motion arcs (flexion contracture and maximum flexion), American Knee Society (AKS) knee and function scores [6], WOMAC scores [1], and SF-36 scores [30]. Flexion contracture and maximum flexion were measured by an investigator (one of the authors) to the nearest 5° using a standard clinical goniometer with patients supine.

The primary outcome variables were postoperative pain levels during the night after surgery and on POD 1, 4, and 7. Pain levels were estimated by patients assisted by a clinical investigator (one of the authors) using a visual analog scale (VAS), which ranged from 0 (no pain) to 10 (worst imaginable pain) scale at a fixed time (5 pm) on POD 1, 4, and 7. Pain level during the night after surgery was assessed by asking patients to recall the most severe pain level experienced when they estimated pain level on POD 1. In addition, patients were asked to rate pain levels vs. preoperative expectations by selecting one of four codes, namely, no pain, less pain than expected, as expected, and more pain than expected. Pain at rest was used to evaluate pain levels during the night after surgery and on POD 1 whereas evaluations conducted on POD 4 and 7 concerned pain at rest, while walking, and during CPM range of motion exercises.

The secondary outcome variables were functional recovery, patient satisfaction, the incidence of wound complications, and drug-related side effects. Functional recoveries were determined based on abilities to perform straight leg raising (SLR) on POD 1 and to achieve maximum flexion on POD 7. Levels of overall patient satisfaction were obtained on day of discharge using 4 grades: enthusiastic, satisfied, non-committed, and disappointed. The wound complications noted were delayed wound healing, prolonged wound drainage, and wound infection. In addition, patients were closely observed postoperatively for narcotic- and ropivacaine-related side effects. The narcotic-related side effects noted were nausea, vomiting, pruritus, urinary retention, and respiratory depression; and the ropivacaine-related side effects were blurred vision, hearing problems, peripheral paresthesia, dizziness, uncontrolled muscle contraction, convulsion, hypotension, bradycardia, headache, and itching.

Statistical analysis

Statistical analyses were conducted using the SPSS for Windows statistical package (version 15.0; SPSS, Chicago, IL), and P values of less than 0.05 were considered significant. The Kolmogorov–Smirnov test was used to determine whether measured and calculated parameters were normally distributed. The Wilcoxon's signed rank test was used to compare VAS pain scores, and the paired t test was used to maximum flexion at POD 7. The Fisher's exact test was used to compare categorical variables (pain levels with reference to preoperative expectations, proportions of patients able to do SLR, and levels of overall patient satisfaction). In addition, the correlation analyses were carried out to investigate the confounding effects of patient factors such as age, weight, height, and BMI.

To determine whether our sample size had sufficient statistical power, we performed *a priori* power analysis using the two-sided hypothesis test at an alpha level of 0.05 and a power of 80%. Seventy-eight knees (39 in each group) were required to detect a two VAS difference in pain level, which we considered clinically significant. Accordingly, the study sample size (110 knees) had sufficient power to detect the differences described earlier.

Results

Knees in the PMDI group were less painful than knees of the No-PMDI group during the operation night and during POD 1, but no significant differences were found between the two groups after POD 1 (Table 1; Fig. 2). Mean VAS pain scores during the operation night and on POD 1 were lower in the PMDI group (3.5 vs. 6.5, $P < 0.001$ and 4.6 vs. 7.5, $P < 0.001$, respectively), and more knees in the PMDI group than in the No-PMDI group had equal to or less than preoperative pain expectations on POD 1 (60% vs. 22%, $P = 0.003$). Interestingly, pain levels during POD 1 were higher than during the first night in both groups, which means that patients experienced rebound pain irrespective of the administration of PMDI ($P = 0.229$). No significant group differences in pain levels were observed on POD 4 and 7 during rest, while walking, and during CPM sessions, or in terms of pain level differences vs. preoperative expectations ($P > 0.5$). In addition, no significant correlations were found between pain levels and patient factors, namely, age, height, weight, and BMI (correlation coefficients <0.1, $P > 0.05$ in all correlations).

The two groups had similar functional recoveries and patient satisfactions, and no clinically detectable drug-related serious side effects were observed in either group. More knees in the PMDI group were able to perform SLR at 24 h after surgery ($P = 0.047$), but no group differences were found with respect to maximum flexion and patient satisfaction on POD 7 (Table 2). No wound complication was occurred in the PMDI group, but one delayed wound discharge beyond POD 5 occurred in the No-PMDI group. The involved knee was successfully treated by wound debridement on POD 7 without residual problems. A substantial number of patients in both groups experienced narcotic-related side effects on POD 1 (Table 3), but no patient experienced a ropivacaine-related side effect.

Discussion

The most important finding of the present study was PMDI provides additional pain relief that was limited to the immediate postoperative period even in patients on

Table 1 Comparisons of pain levels in the PMDI and No-PMDI groups

Parameter	PMDI (N = 55)	No-PMDI (N = 55)	Significance (P value)
Pain score by visual analog scale			
Operation night	3.5 (3.0)	6.6 (3.7)	<0.001
POD 1			
At rest	4.6 (3.1)	7.5 (2.5)	<0.001
POD 4			
At rest	2.3 (2.6)	2.8 (2.9)	0.450
On walking	3.1 (2.5)	3.7 (2.9)	0.337
During CPM	3.8 (2.9)	4.5 (2.9)	0.284
POD 7			
At rest	1.9 (2.1)	2.0 (2.4)	0.963
On walking	3.2 (2.6)	3.5 (2.9)	0.569
During CPM	3.3 (2.8)	3.2 (2.9)	0.898
Pain level with reference to preoperative expectation			
POD 1			0.003
No pain	6 (14.0)	2 (4.7)	
Less than expected	20 (46.5)	7 (16.3)	
As expected	4 (9.3)	4 (9.3)	
More than expected	13 (30.2)	30 (69.7)	
POD 4			0.796
No pain	2 (4.8)	2 (4.8)	
Less than expected	29 (69.0)	25 (61.0)	
As expected	3 (7.1)	5 (12.2)	
More than expected	8 (19.1)	9 (12.0)	
POD 7[a]			0.809
No pain	7 (15.2)	10 (21.7)	
Less than expected	23 (50.0)	19 (41.3)	
As expected	8 (17.4)	8 (17.4)	
More than expected	8 (17.4)	9 (19.6)	

Data are presented as means with standard deviations in parentheses in the visual analog scale, where 0 point indicates no pain and 10 points worst imaginable pain. POD 1, POD 4, and POD 7 = 1, 4, and 7 days postoperatively, respectively; CPM = continuous passive motion

[a] The data of one patient who underwent wound debridement for delayed wound discharge were not included in this calculation

continuous epidural analgesia after simultaneous bilateral TKAs. PMDI-treated knees showed less pain, and significantly, more knees in the PMDI group were less painful or only as painful as preoperative expectations on the first postoperative day. However, no significant differences were found between the two groups on POD 4 or 7. No previous study has evaluated the efficacy of the PMDI and epidural anesthesia combination after TKA. However, from the standpoint of improving early postoperative pain control, this study concurs with recent studies in which the use of PMDI was advocated [3, 15, 19, 27]. On the other

Fig. 2 Graphs show the pain levels with 95% confidence intervals during the operation night (**a**) and on POD 1 (**b**), POD 4 (**c**), and POD 7 (**d**)
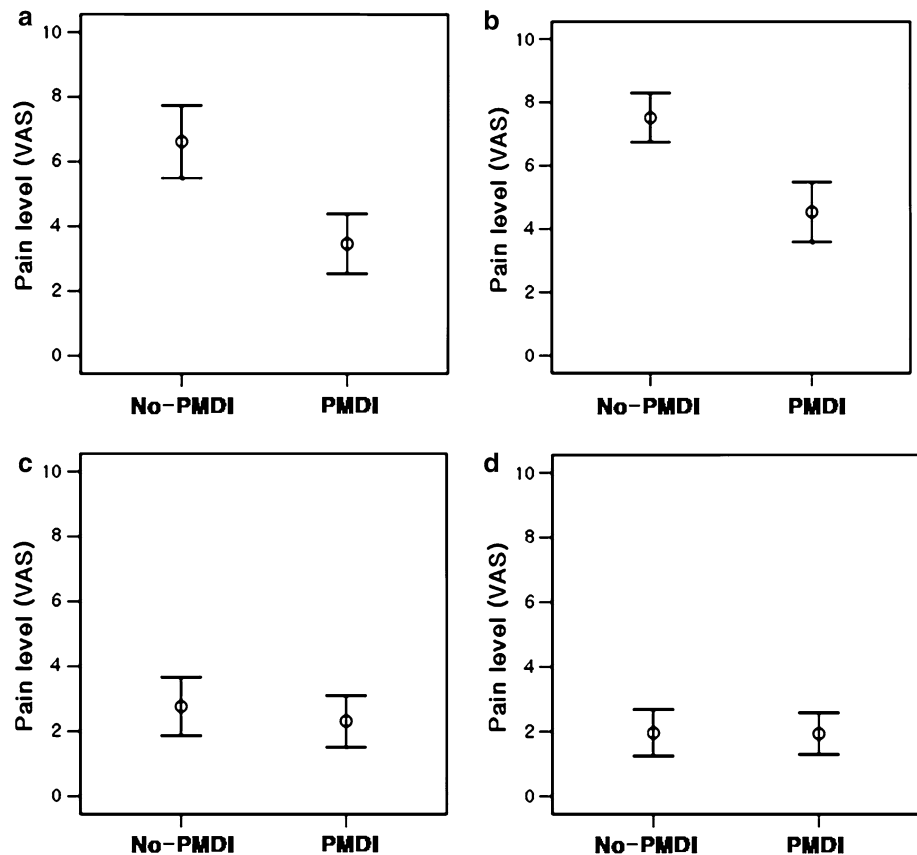

Table 2 Comparisons of functional recoveries and patient satisfactions in the two study groups

Parameters	PMDI (N = 55)	No-PMDI (N = 55)	Significance (P value)
Functional recovery			
Maximal flexion at POD 7[a]	97.4° (14.6)	97.1° (16.4)	0.919
Ability to SLR at POD 1	15 (35.7)	7 (16.7)	0.047
Patient satisfaction at POD 7[a]			
Enthusiastic	5 (9.2)	5 (9.2)	0.973
Satisfied	34 (63.0)	33 (61.1)	
Non-committal	15 (27.8)	16 (29.7)	
Disappointed	0 (0)	0 (0)	

Data are presented as numbers of patients and percentages in parentheses, except for further flexion findings on POD 7, which are presented as means with standard deviations in parentheses

[a] The data of one patient who underwent wound debridement for delayed wound discharge were not included in this calculation

hand, the rebound pain observed, whether PMDI was administered or not, should be considered when designing postoperative pain control protocols or patient education programs. Anecdotally, the delayed and unexpected rebound pain has been observed to increase patient anxiety

or remarkably increase of the consumption of acute pain rescue drugs.

This study does not support the hypothesis that the PMDI improves patient satisfaction, but it does partly support the hypothesis that the PMDI improves functional recovery. The ability to SLR on POD 1 tended to be more frequent in the PMDI group. However, no group differences were found for maximum flexion and patient satisfaction on POD 7, indicating that PMDI has little or no long-term clinical benefit. Furthermore, the finding of no difference in maximum flexion on POD 7 concurs with several previous studies, which concluded that PMDI provides no significant functional improvement [3, 19, 27].

This study arguably confirms the safety of the PMDI procedure, which has been documented on several occasions [3, 13, 18, 19, 25, 27]. Initially, it was concerned that wound complications might be increased by the administrations of PMDI. However, no wound complication occurred in the PMDI group, and on the contrary, one knee of the No-PMDI group developed delayed wound discharge beyond POD 5. Due to the low incidence of wound complications, this study does not have sufficient power to draw a conclusion about the incidence of wound complications. However, our finding of no occurrence of wound complications in the PMDI group may arguably defy our concerns on increased risks for wound complications by

Table 3 The incidences of opioid-related side effects

Parameters	Number of patients
POD 1	
Nausea/vomiting	25 (45.4)
Pruritus	14 (25.5)
Urinary retention[a]	Not applicable
Respiratory depression	0 (0)
POD 4	
Nausea/vomiting	3 (5.5)
Pruritus	3 (5.5)
Urinary retention	0 (0)
Respiratory depression	0 (0)

Data are presented as numbers of patients that experienced a side effect or complication with proportions in parentheses

[a] Not applicable because a Foley catheter was retained on POD 1. POD 1 and POD 4 = 1 and 4 days postoperatively

PMDI. Furthermore, the incidences of narcotic-related side effects were similar in the two groups, which agrees with previous studies [9, 21, 25, 27], and no patient experienced a ropivacaine-related side effect.

Several study limitations should be noted. First, 96% (53/55) of this cohort was women. For some unknown reason, this female dominance is more pronounced in Korean patients [10, 11]. Furthermore, this cohort had a mean age of 67.4 years. Thus, this study concerns mainly elderly female subjects. Because gender, age, and culture can influence pain perceptions, these cohort-related characteristics should be considered before attempting to extrapolate our findings to other patient populations. Second, patients' knees were randomly assigned to two treatment groups, and PMDI was not administered into both knees in any subject. Thus, we consider this study is a preliminary report. A further study comparing a study group of both knees treated with PMDI and a control group of no knees treated with PMDI is required to investigate the efficacy and safety of PMDI. Third, plasma levels of ropivacaine after infiltration were not been measured. Therefore, a solid conclusion could not be drawn about the occurrence of ropivacaine-related side effects. However, in the present study, no ropivacaine-induced systemic toxicity was observed. Furthermore, two previous studies reported that toxic plasma levels were not reached after infiltration of 400 mg ropivacaine [3, 27], which is a greater dose than that used in the present study. Finally, the assessment timings for pain levels during the operation night and at 24 h after surgery might have differed because surgeries were completed at different times, and the assessments were performed at a fixed time point. Nevertheless, in view of the extended analgesic effect of continuous epidural

analgesia, the time points used in this study were believed to be adequate. Furthermore, pain assessment by a single investigator in a ward is considered to be more accurate and reliable than assessments performed by different health care providers.

This study demonstrates that PMDI provides additional pain relief in patients on continuous epidural analgesia after simultaneous bilateral TKAs, but the pain-relieving effects would last only postoperative 1 day. In addition, this study found that patient satisfaction and functional recovery were not improved by PMDI. Therefore, PMDI should be considered as an effective, but short-term, supplementary component, and not as a substitute for other modalities incorporated into multimodal analgesic strategies in patients undergoing simultaneous bilateral TKAs.

Conclusion

Periarticular multimodal drug injections (PMDI) provides additional pain relief in patients on continuous epidural analgesia, but the additional pain-relieving effects would be limited to the immediate postoperative period without functional recovery improvement or patient satisfaction.

References

1. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW (1988) Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol 15:1833–1840
2. Block BM, Liu SS, Rowlingson AJ, Cowan AR, Cowan JA Jr, Wu CL (2003) Efficacy of postoperative epidural analgesia: a meta-analysis. JAMA 290:2455–2463
3. Busch CA, Shore BJ, Bhandari R, Ganapathy S, MacDonald SJ, Bourne RB, Rorabeck CH, McCalden RW (2006) Efficacy of periarticular multimodal drug injection in total knee arthroplasty. A randomized trial. J Bone Joint Surg Am 88:959–963
4. Cohen RG, Forrest CJ, Benjamin JB (1997) Safety and efficacy of bilateral total knee arthroplasty. J Arthroplasty 12:497–502
5. Hebl JR, Dilger JA, Byer DE, Kopp SL, Stevens SR, Pagnano MW, Hanssen AD, Horlocker TT (2008) A pre-emptive multimodal pathway featuring peripheral nerve block improves perioperative outcomes after major orthopedic surgery. Reg Anesth Pain Med 33:510–517
6. Insall JN, Dorr LD, Scott RD, Scott WN (1989) Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 248:13–14
7. Johanson NA, Lachiewicz PF, Lieberman JR, Lotke PA, Parvizi J, Pellegrini V, Stringer TA, Tornetta P 3rd, Haralson RH 3rd, Watters WC 3rd (2009) Prevention of symptomatic pulmonary embolism in patients undergoing total hip or knee arthroplasty. J Am Acad Orthop Surg 17:183–196
8. Kampe S, Weigand C, Kaufmann J, Klimek M, Konig DP, Lynch J (1999) Postoperative analgesia with no motor block by

continuous epidural infusion of ropivacaine 0.1% and sufentanil after total hip replacement. Anesth Analg 89:395–398

9. Kerr DR, Kohan L (2008) Local infiltration analgesia: a technique for the control of acute postoperative pain following knee and hip surgery: a case study of 325 patients. Acta Orthop 79:174–183

10. Kim HA, Kim S, Seo YI, Choi HJ, Seong SC, Song YW, Hunter D, Zhang Y (2008) The epidemiology of total knee replacement in South Korea: national registry data. Rheumatology (Oxford) 47:88–91

11. Kim JM, Moon MS (1995) Squatting following total knee arthroplasty. Clin Orthop Relat Res 313:177–186

12. Kopacz DJ, Sharrock NE, Allen HW (1999) A comparison of levobupivacaine 0.125%, fentanyl 4 microg/mL, or their combination for patient-controlled epidural analgesia after major orthopedic surgery. Anesth Analg 89:1497–1503

13. Lombardi AV Jr, Berend KR, Mallory TH, Dodds KL, Adams JB (2004) Soft tissue and intra-articular injection of bupivacaine, epinephrine, and morphine has a beneficial effect after total knee arthroplasty. Clin Orthop Relat Res 428:125–130

14. Lu H, Mehdi G, Zhou D, Lin J (1996) Simultaneous bilateral total knee arthroplasty for rheumatoid arthritis. Chin Med J 109:937–940

15. Maheshwari AV, Blum YC, Shekhar L, Ranawat AS, Ranawat CS (2009) Multimodal pain management after total hip and knee arthroplasty at the Ranawat orthopaedic center. Clin Orthop Relat Res 467:1418–1423

16. Mahoney OM, Noble PC, Davidson J, Tullos HS (1990) The effect of continuous epidural analgesia on postoperative pain, rehabilitation, and duration of hospitalization in total knee arthroplasty. Clin Orthop Relat Res 260:30–37

17. Park KK, Shin KS, Chang CB, Kim SJ, Kim TK (2007) Functional disabilities and issues of concern in female Asian patients before TKA. Clin Orthop Relat Res 461:143–152

18. Parvataneni HK, Ranawat AS, Ranawat CS (2007) The use of local periarticular injections in the management of postoperative pain after total hip and knee replacement: a multimodal approach. Instr Course Lect 56:125–131

19. Parvataneni HK, Shah VP, Howard H, Cole N, Ranawat AS, Ranawat CS (2007) Controlling pain after total hip and knee arthroplasty using a multimodal protocol with local periarticular injections: a prospective randomized study. J Arthroplasty 22:33–38

20. Parvizi J, Porat M, Gandhi K, Viscusi ER, Rothman RH (2009) Postoperative pain management techniques in hip and knee arthroplasty. Instr Course Lect 58:769–779

21. Peters CL, Shirley B, Erickson J (2006) The effect of a new multimodal perioperative anesthetic regimen on postoperative pain, side effects, rehabilitation, and length of hospital stay after total joint arthroplasty. J Arthroplasty 21:132–138

22. Powell RS, Pulido P, Tuason MS, Colwell CW Jr, Ezzet KA (2006) Bilateral vs unilateral total knee arthroplasty: a patient-based comparison of pain levels and recovery of ambulatory skills. J Arthroplasty 21:642–649

23. Ranawat AS, Ranawat CS (2007) Pain management and accelerated rehabilitation for total hip and total knee arthroplasty. J Arthroplasty 22:12–15

24. Sinatra RS, Torres J, Bustos AM (2002) Pain management after major orthopaedic surgery: current strategies and new concepts. J Am Acad Orthop Surg 10:117–129

25. Toftdahl K, Nikolajsen L, Haraldsted V, Madsen F, Tonnesen EK, Soballe K (2007) Comparison of peri- and intraarticular analgesia with femoral nerve block after total knee arthroplasty: a randomized clinical trial. Acta Orthop 78:172–179

26. Trousdale RT, McGrory BJ, Berry DJ, Becker MW, Harmsen WS (1999) Patients' concerns prior to undergoing total hip and total knee arthroplasty. Mayo Clin Proc 74:978–982

27. Vendittoli PA, Makinen P, Drolet P, Lavigne M, Fallaha M, Guertin MC, Varin F (2006) A multimodal analgesia protocol for total knee arthroplasty. A randomized, controlled study. J Bone Joint Surg Am 88:282–289

28. Viscusi ER (2005) Emerging techniques in the management of acute pain: epidural analgesia. Anesth Analg 101:S23–S29

29. Viscusi ER, Parvizi J, Tarity TD (2007) Developments in spinal and epidural anesthesia and nerve blocks for total joint arthroplasty: what is new and exciting in pain management. Instr Course Lect 56:139–145

30. Ware JE Jr, Sherbourne CD (1992) The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 30:473–483

31. Wheatley RG, Schug SA, Watson D (2001) Safety and efficacy of postoperative epidural analgesia. Br J Anaesth 87:47–61

32. Zaric D, Boysen K, Christiansen C, Christiansen J, Stephensen S, Christensen B (2006) A comparison of epidural analgesia with combined continuous femoral-sciatic nerve blocks after total knee replacement. Anesth Analg 102:1240–1246

33. Zeni JA Jr, Snyder-Mackler L (2009) Clinical outcomes after simultaneous bilateral total knee arthroplasty comparison to unilateral total knee arthroplasty and healthy controls. J Arthroplasty Apr 7. [Epub ahead of print]