ORIGINAL ARTICLE

Acta Orthop Traumatol Turc 2014;48(1):73-79
doi: 10.3944/AOTT.2014.3256

A comparison of epidural analgesia and local infiltration analgesia methods in pain control following total knee arthroplasty

Eylem BİNİCİ BEDİR[1], Tuhan KURTULMUŞ[2], Selma BAŞYİĞİT[3], Uğur BAKIR[2], Necdet SAĞLAM[2], Gürsel SAKA[2]

[1]Department of Anesthesiology and Reanimation, Bilecik State Hospital, Bilecik, Turkey;
[2]Department of Orthopedics and Traumatology, Umraniye Training and Research Hospital, Istanbul, Turkey;
[3]Department of Anesthesiology and Reanimation, Viransehir State Hospital, Sanliurfa, Turkey

Objective: The aim of this study was to compare the effects of epidural analgesia with infiltration analgesia in postoperative pain control for total knee arthroplasty.

Methods: Thirty patients (28 female, 2 male; mean age: 69.37±5.11 years, range: 61 to 80 years) undergoing total knee arthroplasty between May 2011 and September 2011 were randomly divided into 2 groups. All patients received spinal anesthesia with bupivacaine. Postoperative analgesia of 72 ml 0.9% NaCl + 48 ml bupivacaine (1 ml = 5 mg, total 120 ml) was administered throughout 24 hours to Group 1 (n=15) by epidural catheter and to Group 2 (n=15) by ON-Q infiltration pump. Groups were compared based on the Bromage scores and visual analog scale (VAS), blood pressure, postoperative analgesia requirement and side effects.

Results: Demographic data were similar in both groups. Rates of additional analgesia requirement at the postoperative 60th minute and 2nd hour were significantly higher in Group 2 than Group 1 ($p<0.05$). Rates of nausea-vomiting at the postoperative 60th minute and 2nd hour were significantly higher in Group 1 than Group 2 ($p<0.05$ and $p<0.01$, respectively). Bromage scores at 60 minutes and 2 hours was significantly higher in Group 1 than in Group 2 ($p<0.01$). Mean VAS scores at 60 minutes and 2 hours were significantly higher in Group 2 than Group 1 ($p<0.05$). While a statistically significant difference was found between systolic arterial pressure measurements at 60 minutes ($p<0.05$), there was no significant difference in diastolic arterial pressure and peak heart rate.

Conclusion: Although the analgesic effect of local infiltration is provided later than by epidural analgesia, the same level of pain control can be achieved with initial additional analgesia. Local infiltration is superior to epidural analgesia in respect of few side effects and early mobilization.

Key words: Epidural analgesia; knee arthroplasty; local infiltrative analgesia; postoperative pain.

Postoperative pain is an acute pain that begins following the trauma of surgery and ends with tissue healing. Reflex, endocrine, metabolic and inflammatory responses can occur when pain is not brought under control.[1] As a result, severe complications such as pulmonary, cardiac and renal problems and thromboembolism may develop.

Correspondence: Eylem Binici Bedir, MD. Bilecik Devlet Hastanesi, Anestezi ve Reanimasyon Kliniği, Merkez, Bilecik, Turkey
Tel: +90 228 – 212 10 36 e-mail: eylem_binici@yahoo.com

Submitted: April 11, 2013 **Accepted:** September 10, 2013

Available online at
www.aott.org.tr
doi: 10.3944/AOTT.2014.3256
QR (Quick Response) Code

[2,3] Pain may also prevent or restrict postoperative physiotherapy.[4,5]

While postoperative pain is said to be affected by age, gender, psychological status, pharmacokinetic and pharmacodynamic agents, premedication and anesthesia used, the anatomical area in which the surgery is performed remains the most significant factor.[6]

Epidural infusion techniques using catheters placed over the subarachnoid space or the peripheral nerves are in widespread current use for patients with acute and chronic pain.[6] Continuous infusion by catheter is an effective method for postoperative pain relief as the local effect with low doses of medication significantly reduces side effects.[6]

Local anesthesia (LA) infiltration in the form of plexus block, intercostal block, interpleural block, epidural block or subarachnoid block is used in the treatment of pain.[7,8] Local anesthesia is commonly selected for the treatment of postoperative pain as of its application to the surgical site is practical and easy and achieves effective analgesia.[9]

This study aimed to compare the effects on postoperative pain of an infiltrative local anesthesia/analgesia method located subcutaneously with that of an epidural analgesia technique applied by the surgeon over the fascia at the end of the operation.

Patients and methods

A total of 30 cases (28 female, 2 male; mean age: 69.37±5.11 years; range: 61 to 80 years) patients who underwent primary total knee arthroplasty (TKA) between May 2011 and September 2011 were included in this prospective, randomized study. Informed consent was obtained from all patients. Patients classified as ASA 2-3[10] were included while those sensitive to local anesthesia, morbidly obese or who had additional pathologies which might constitute a contraindication to regional anesthesia were excluded from the study.

Patients were randomly divided into 2 groups of 15. The severity of preoperative pain was assessed in all patients.

Patients were monitored on the operating table with electrocardiography (ECG), arterial blood pressure (BP) and oxygen saturation (SaO_2). Spinal anesthesia technique was applied to both groups. In the operating theater preparation room, volume replacement was made with 10 ml/kg 0.9% NaCl (Eczacıbaşı-Baxter Hospital Supply Inc., Istanbul, Turkey) solution through a vein opened with a 20-gauge (G) (Bio-flon) intravenous cannula. A tourniquet was used on all patients of both groups. A midline skin incision was made and the joint was reached with a median parapatellar approach. Ligament sparing cemented total knee prosthesis was applied to all patients. The patella surface was not changed in any patient.

In Group 1 patients, the epidural space was entered through the defined space at the midline and with the loss of resistance method using an 18G Tuohy epidural needle (Espocan®; B. Braun Melsungen AG, Melsungen, Germany) at the lumbar L4-L5, L5-S1 sacral space. By passing a spinal needle inside the epidural needle, entrance to the subarachnoid space was determined with the free flow of cerebral spinal fluid (CSF). Spinal anesthesia was achieved with 3 cc of hyperbaric bupivacaine (Marcaine Spinal Heavy; AstraZeneca, Turkey). The epidural catheter was placed with 5 cm remaining in the epidural space and was fixed by attaching an adaptor. The catheter placement was confirmed with a test of 3 ml (60 mg) lidocaine. In Group 2 patients, the L4-L5, L5-S1 space was defined and entrance to the subarachnoid space with a 22G spinal needle (Exel; Alkim Ltd., Ankara, Turkey) was determined with the free flow of CSF. Spinal anesthesia was achieved with 3 cc of hyperbaric bupivacaine.

In the postoperative recovery room, when a Bromage score of 2 was reached (Bromage scores: 0: no paralysis, full movement of the ankle and knee, 1: patient can only move the knee and ankle, the leg cannot be raised straight, 2: patient cannot move the knee, only the ankle can be moved, 3: full paralysis[11]), a patient-controlled analgesia pump (CADD-Legacy; Smiths Medical UK, Kent, UK) was placed on the epidural catheter with a 120 ml prepared solution of 72 ml 0.9% NaCl + 48 ml bupivacaine (1 ml = 5 mg) in Group 1 patients. The patient-controlled pump was prepared as a 5 cc/hour continuous infusion for 24 hours. In Group 2 patients, an infiltrative analgesia pump was placed at the end of surgery by the surgeon over the fascia parallel to the incision line so that all the holes of the catheter remained under the skin. The catheter was fixed by suturing the skin (Fig. 1) and a 16-hole ON-Q pump was attached to the catheter. Postoperative pain control was achieved with 120 ml solution of 72 ml 0.9% NaCl + 48 ml bupivacaine (1ml = 5 mg) at an infusion rate of 5 ml/hour for 24 hours. The ON-Q pump infusion was begun in the postoperative recovery room when a Bromage score of 2 was reached. For all patients, analgesia was administered for 24 hours and catheters were removed.

For all patients, additional analgesia of non-steroid anti-inflammatory 75mg/3ml diclofenac sodium (Diclomec; Abdi Ibrahim Ilac, Istanbul, Turkey) was adminis-

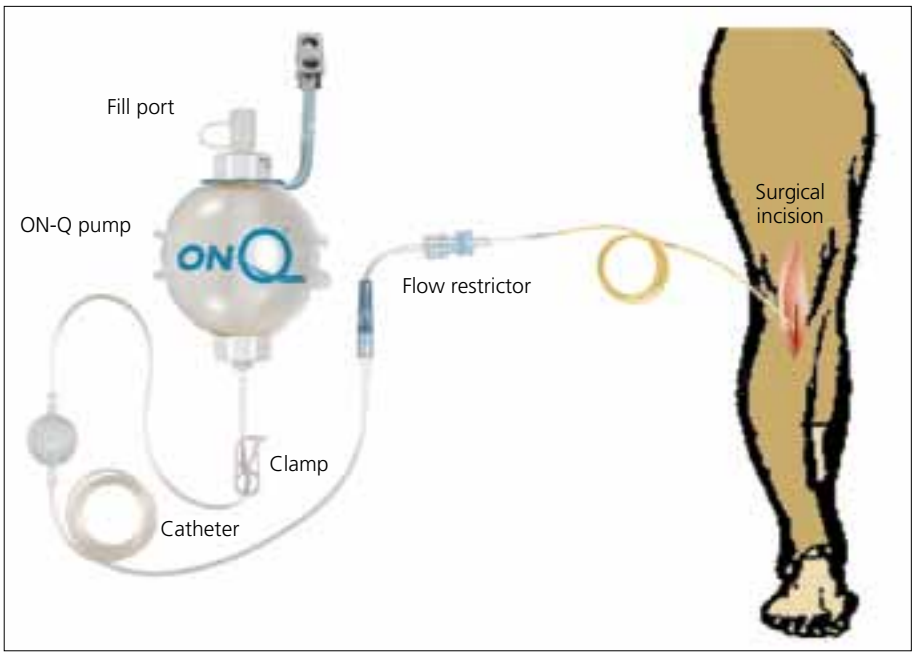

Fig. 1. Placement of the end of the ON-Q pain pump catheter over the fascia following TKA surgery.[20,21] [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

tered when visual analog scale (VAS) scores were ≥4.[12] Nausea-vomiting, irritation, peak heart rate, systolic arterial pressure (SAP), diastolic arterial pressure (DAP), the need for additional analgesia and urine retention were recorded at the postoperative 30th and 60th minutes and 2nd, 8th, 12th and 24th hours.

Two patients were excluded from the study as the epidural anesthesia leaked from the epidural catheter and postoperative motor block developed.

Weight-bearing as tolerated was permitted on postoperative Day 1 by sitting and standing with the help of a walking frame. In addition, on the first day, ankle dorsiflexion-plantarflexion, isometric exercises for the quadriceps muscle, straight leg raises and active flexion extension for the knee joint were applied. Walking was started on Day 2.

The NCSS (Number Cruncher Statistical System) 2007 and PASS (Power Analysis and Sample Size) 2008 Statistical Software (NCSS LLC, Kaysville, UT, USA) were used for statistical analysis. Data were expressed as mean, standard deviation, median and frequency. The Mann-Whitney U-test was used for intergroup comparison of quantitative data. The Wilcoxon signed-rank test was used in the comparison within groups. The chi-square test and Fisher's exact chi-square test were used for the comparison of qualitative data. Results were evaluated in a confidence interval of 95% and at a significance level of $p<0.05$.

Results

Mean age in Group 1 (15 females) was 70.80±5.39 years and 67.93±4.54 years in Group 2 (13 females, 2 males). No statistically significant difference was determined between the groups in terms of age or gender ($p>0.05$).

The time taken postoperatively to reach Bromage score 2 was a mean of 27.33±9.23 minutes in Group 1 and 22.00±9.96 minutes in Group 2. No statistically significant difference was determined ($p>0.05$).

While there was no significant difference between groups at 30 minutes ($p>0.05$), Bromage scores of Group 1 were significantly higher than Group 2 at 60 minutes and 2 hours ($p<0.01$). At the 8th, 12th and 24th hours, there was no statistically significant difference in Bromage scores ($p>0.05$) (Table 1).

No statistically significant difference was determined between the mean VAS scores at 30 minutes, 8 hours and 12 hours ($p>0.05$). Mean VAS scores at 60 minutes and 2 hours were statistically significantly higher in Group 2 than in Group 1 ($p<0.05$). At postoperative 24 hours, VAS scores of all cases were 0 (Table 2).

At 30 minutes, 2 cases (13.3%) in Group 1 and 5 cases (33.3%) in Group 2 required additional analgesia. No statistically significant difference was determined ($p>0.05$). At 60 minutes, there was a statistically significant difference between the need for additional analgesia in Group 2 (5 cases; 33.3%) and Group 1 (0

Table 1. Evaluation of Bromage scores of both groups.

	Group 1 (n=15) Bromage score				Group 2 (n=15) Bromage score				p
	0	1	2	Median	0	1	2	Median	
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)		
30 min	1 (6.7)	1 (6.7)	13 (86.7)	2	1 (6.7)	5 (33.3)	9 (60.0)	2	0.133
60 min	2 (13.3)	3 (20.0)	10 (66.7)	2	9 (60.0)	5 (33.3)	1 (6.7)	0	0.001*
2 hrs	9 (60.0)	5 (33.3)	1 (6.7)	1	15 (100)	0 (0)	0 (0)	0	0.007*
8 hrs	15 (100)	0 (0)	0 (0)	0	15 (100)	0 (0)	0 (0)	0	1.000
12 hrs	15 (100)	0 (0)	0 (0)	0	15 (100)	0 (0)	0 (0)	0	1.000
24 hrs	15 (100)	0 (0)	0 (0)	0	15 (100)	0 (0)	0 (0)	0	1.000

Mann-Whitney U-test. *p<0.01.

Table 2. Evaluation of VAS scores of both groups.

	VAS scores					
	30 min	60 min	2 hrs	8 hrs	12 hrs	24 hrs
Group 1						
Mean±SD (median)	3.60±4.03 (2)	2.53±2.97 (2)	2.47±3.14 (0)	1.33±1.84 (0)	0.73±1.44 (0)	0
Group 2						
Mean±SD (median)	6.20±2.88 (7)	5.20±1.90 (5)	5.20±2.98 (6)	1.93±2.34 (2)	0.40±0.83 (0)	0
p	0.137	0.011*	0.026*	0.512	0.713	0

Mann-Whitney U test. *p<0.05. VAS: Visual analog scale; SD: Standard deviation.

Table 3. Evaluation of the rates of need for additional analgesia in both groups.

	Need for analgesia					
	*30 min	*60 min	2 hrs	*8 hrs	12 hrs	24 hrs
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Group 1	2 (13.3)	0 (0)	4 (26.7)	0 (0)	0 (0)	0 (0)
Group 2	5 (33.3)	5 (33.3)	10 (66.7)	2 (13.3)	0 (0)	0 (0)
p	0.390	0.042†	0.028†	0.483	–	–

Chi-square test. *Fisher's exact chi-square test. †p<0.05.

cases) (p<0.05). At the 2nd postoperative hour, 10 cases (66.7%) in Group 2 and 4 cases (26.7%) in Group 1 required additional analgesia and this difference was statistically significant (p<0.05). While 2 cases (13.3%) in Group 2 and 0 cases in Group 1 required additional analgesia at the 8th postoperative hour, this difference was not statistically significant (p>0.05). No cases required additional analgesia at the 12th and 24th postoperative hours (Table 3).

No statistically significant difference was determined between the SAP measurements at 30 minutes, 2, 8, 12 and 24 hours (p>0.05). The mean SAP at 60 minutes were significantly higher in Group 2 than in Group 1 (p<0.05).

There were no statistically significant differences in DAP or peak heart rate between groups at all times (p>0.05).

At 60 minutes the rate of nausea-vomiting of Group 1 was significantly higher than that of Group 2 (p<0.05). At the 2nd postoperative hour, the rate of nausea-vomiting of Group 1 was significantly higher than that of Group 2 (p<0.01). No statistical differences were determined at any other times of measurement (Table 4).

Table 4. Evaluation of nausea-vomiting rates in both groups.

	Nausea-Vomiting					
	30 min	**60 min**	***2 hrs**	***8 hrs**	**12 hrs**	**24 hrs**
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Group 1	7 (46.7)	8 (53.3)	9 (60.0)	2 (13.3)	0 (0)	0 (0)
Group 2	4 (26.7)	2 (13.3)	0 (0)	0 (0)	0 (0)	0 (0)
p	0.256	0.020†	0.001‡	0.483	–	–

Chi-square test. *Fisher's exact chi-square test. †p<0.05, ‡p<0.01.

No cases of irritation or urine retention were observed in the study. Follow-up related to pain after the first 24 hours was performed clinically. Apart from for mobilization, there was no need for additional analgesia.

Discussion

Postoperative pain experienced by TKA patients is severe in 60% of cases and moderate in 30%.[1] Multimodal techniques of anesthesia are more effective in pain control for the reduction of analgesia use for these patients and avoidance of side effects.[13] The use of regional anesthesia methods, and local infiltrative analgesia methods in particular, achieves lower rates of nausea-vomiting, deep vein thrombosis, pulmonary embolism, myocardial infarction, pneumonia and delirium in this group of patients.[14]

Continuous LA infusion has been applied with success for postoperative pain relief in anterior cruciate ligament reconstruction,[15] rotator cuff repair,[16] spinal fusion,[17] iliac graft damage[18] and TKA.[19]

Local anesthesia infusion at a fixed rate is provided by a pump and balloon from a catheter. The number and length of catheters is defined by the size and location of the surgical site. The infusion must be used to provide a specific amount and concentration of LA within the surgical site. In this study, a multi-holed single catheter ON-Q pain pump system was used to provide infusion at a specific rate according to the size of the surgical site (Fig. 1).[20,21] The administration of 0.25% bupivacaine infusion at 4 ml/hour with the ON-Q pain pump system reduces the need for opioids by 40%, without any side effects.[22] In the current study, an infusion of 240 mg/day of bupivacaine at 0.5% concentration at 5 ml/hour was applied using the ON-Q pain pump system. There were no findings of local anesthesia substance toxicity and no catheter-related complications developed during the follow-up.

In cases in which the catheter is placed in the surgical area, problems may occur, such as the suturing of the catheter to the soft tissue, movement of the catheter out of place, blockage resulting in disruption of the continuity of the infusion, hematoma, and infection. Infection is the most significant anticipated catheter-related complication.[20,21,23-26]

The end of the catheter must be placed in the soft tissue outside the joint or close to the incision. Moreover, when the end of the catheter is placed intraarticularly, the effect of the administered local anesthesia is reduced by the Hemovac drain and a chondrotoxic effect is caused.[19] In the current study, the end of the catheter of the infiltrative pain pump was placed over the fascia in the subcutaneous tissue.

Infiltrative analgesia applied for postoperative TKA pain control allows for early mobilization as it does not weaken the muscles.[27,28] The application of continuous epidural analgesia has been reported to lengthen motor block compared to local infiltrative analgesia.[14] In the current study, the duration of motor block in patients to whom epidural analgesia was applied was longer than that of the local infiltrative analgesia group. In a study of 102 patients undergoing TKA, VAS scores of patients receiving continuous epidural infusion were lower than those receiving infiltrative analgesia with local ketorolac and morphine or intravenous ketorolac and morphine and intermittent infiltration analgesia in the first 4 hours, while they were lowest in the intravenous ketorolac and morphine group in the following 72 hours.[29] These findings are in line with those of the current study.

More nausea-vomiting has been reported to occur with morphine than with infiltrative analgesia.[30,31] In the current study, the rates of nausea-vomiting at 60 minutes and 2 hours were significantly higher in patients cases receiving an epidural pain pump than local infiltrative analgesia. This can be considered a disadvantage of the epidural method.

In a study comparing epidural analgesia and systemic analgesia in postoperative TKA pain control, hypotension was seen more frequently in the epidural analgesia

group.[32] In the current study, the SAP values of the epidural group were lower than those of the infiltrative pain pump group.

While epidural analgesia provides pain control in a shorter time, patients receiving local infiltrative analgesia show a need for additional analgesia in the early stages. However, effective analgesia is provided by both methods in subsequent hours.[33] In the current study, a significantly higher rates of patients in the infiltrative pain pump group required additional analgesia at 60 minutes and 2 hours, although there was no difference between the groups subsequently.

In a study comparing postoperative pain control with high dosage local infiltration analgesia, epidural analgesia and intravenous morphine + ketorolac combination, higher rates of irritation and urine retention were seen in the epidural analgesia group.[29] In the current study, no cases of irritation and urine retention were observed.

In studies conducted on postoperative TKA pain control, it has been reported that various agents can be used in combination to provide infiltrative analgesia. In a study[34] comparing the analgesic effect and tolerability of repeated doses of intravenous paracetamol hydrochloride and intramuscular diclofenac in the treatment of postoperative pain following total hip arthroplasty, the intravenous paracetamol group obtained a greater reduction in pain scores than the placebo group at 60 minutes while there was no difference between the diclofenac group and the placebo group. The effect provided by 2 infusions of intravenous 1 g of paracetamol at 5-hour intervals was similar to that provided by an intramuscular injection of 75 mg diclofenac and there was no significant difference between the intravenous paracetamol group and the diclofenac group at the 5th and 10th hours after dose administration. In the current study, only LA (0.02% bupivacaine) was used as infiltrative analgesia. In patients where effective pain control was not achieved, intramuscular diclofenac was administered as a non-steroid anti-inflammatory drug. In the current study, cases using the local infiltrative pain pump had a significantly higher need for analgesia at 2 hours than those using the epidural pain pump. After the 2nd hour there was no difference between the two groups in need for additional analgesia.

In conclusion, epidural analgesia provides effective pain control despite the disadvantages of its invasiveness, late return of motor functions and more systemic side effects. While the ON-Q pain pump system used for local infiltration analgesia is reliable and simple to use, there is a greater need for additional analgesia than in the epidural analgesia method at initial stages until pain is brought under control. However, in postoperative pain control, local infiltrative analgesia methods should be considered due to its ease of use, lower rates of systemic side effects and the fact that it does not extend the motor block or require systemic application of LA.

Conflicts of Interest: No conflicts declared.

References

1. Bonica J. Postoperative pain. In: Bonica J, editor. The management of pain. 2nd ed. Philadelphia, PA: Lea & Febiger; 1990. p. 461-80.
2. Allen HW, Liu SS, Ware PD, Nairn CS, Owens BD. Peripheral nerve blocks improve analgesia after total knee replacement surgery. Anesth Analg 1998;87:93-7. CrossRef
3. Kehlet H. Surgical stress: the role of pain and analgesia. Br J Anaesth 1989;63:189-95. CrossRef
4. Ryu J, Saito S, Yamamoto K, Sano S. Factors influencing the postoperative range of motion in total knee arthroplasty. Bull Hosp Jt Dis 1993;53:35-40.
5. Shoji H, Solomonow M, Yoshino S, D'Ambrosia R, Dabezies E. Factors affecting postoperative flexion in total knee arthroplasty. Orthopedics 1990;13:643-9.
6. Wiebalck A, Brodner G, Van Aken H. The effects of adding sufentanil to bupivacaine for postoperative patient-controlled epidural analgesia. Anesth Analg 1997;85:124-9.
7. Keskin A. Role of pain in operative strategy. [Article in Turkish] Ağrı 2004;6:42-3.
8. Erdine S. Postoperative analgesia. Pain syndromes and management. [Article in Turkish] Istanbul; 2003. p. 33-43.
9. Elder JB, Hoh DJ, Wang MY. Postoperative continuous paravertebral anesthetic infusion for pain control in lumbar spinal fusion surgery. Spine (Phila Pa 1976) 2008;33:210-8. CrossRef
10. American Society of Anesthesiologists. New classification of physical status. Anesthesiology 1963;24:111.
11. Morgan GE, Mikhail MS, Murray MJ, editors. Clinical anesthesiology. New York, NY: Lange Medical Books/McGraw-Hill; 2002. p. 309-58.
12. Katz J, Melzack R. Measurement of pain. Surg Clin North Am 1999;79:231-52. CrossRef
13. Maheshwari AV, Blum YC, Shekhar L, Ranawat AS, Ranawat CS. Multimodal pain management after total hip and knee arthroplasty at the Ranawat Orthopaedic Center. Clin Orthop Relat Res 2009;467:1418-23. CrossRef
14. Starks I, Frost A, Wall P, Lim J. Is a fracture of the transverse process of L5 a predictor of pelvic fracture instability? J Bone Joint Surg Br 2011;93:967-9. CrossRef
15. Hoenecke HR Jr, Pulido PA, Morris BA, Fronek J. The efficacy of continuous bupivacaine infiltration following anterior cruciate ligament reconstruction. Arthroscopy

2002;18:854-8. CrossRef
16. Gottschalk A, Burmeister MA, Radtke P, Krieg M, Farokhzad F, Kreissl S, et al. Continuous wound infiltration with ropivacaine reduces pain and analgesic requirement after shoulder surgery. Anesth Analg 2003;97:1086-91. CrossRef
17. Bianconi M, Ferraro L, Ricci R, Zanoli G, Antonelli T, Giulia B, et al. The pharmacokinetics and efficacy of ropivacaine continuous wound instillation after spine fusion surgery. Anesth Analg 2004;98:166-72. CrossRef
18. Singh K, Samartzis D, Strom J, Manning D, Campbell-Hupp M, Wetzel FT, et al. A prospective, randomized, double-blind study evaluating the efficacy of postoperative continuous local anesthetic infusion at the iliac crest bone graft site after spinal arthrodesis. Spine (Phila Pa 1976) 2005;30:2477-83. CrossRef
19. Argintar E, Armstrong B, Zawadsky M, Evans B, Romness D. Pain control infusion pumps: a prospective randomized evaluation in bilateral total knee arthroplasty. Orthopedics 2011;34:188.
20. Forastiere E, Sofra M, Giannarelli D, Fabrizi L, Simone G. Effectiveness of continuous wound infusion of 0.5% ropivacaine by On-Q pain relief system for postoperative pain management after open nephrectomy. Br J Anaesth 2008;101:841-7. CrossRef
21. LeBlanc KA, Bellanger D, Rhynes VK, Hausmann M. Evaluation of continuous infusion of 0.5% bupivacaine by elastomeric pump for postoperative pain management after open inguinal hernia repair. J Am Coll Surg 2005;200:198-202. CrossRef
22. Givens VA, Lipscomb GH, Meyer NL. A randomized trial of postoperative wound irrigation with local anesthetic for pain after cesarean delivery. Am J Obstet Gynecol 2002;186:1188-91. CrossRef
23. Wheatley GH 3rd, Rosenbaum DH, Paul MC, Dine AP, Wait MA, Meyer DM, et al. Improved pain management outcomes with continuous infusion of a local anesthetic after thoracotomy. J Thorac Cardiovasc Surg. 2005;130:464-8. CrossRef
24. Baig MK, Zmora O, Derdemezi J, Weiss EG, Nogueras JJ, Wexner SD. Use of the ON-Q pain management system is associated with decreased postoperative analgesic requirement: double blind randomized placebo pilot study. J Am Coll Surg 2006;202:297-305. CrossRef
25. Charous S. Use of the ON-Q pain pump management system in the head and neck: preliminary report. Otolaryngol Head Neck Surg 2008;138:110-2. CrossRef
26. Shen-Gunther J. ON-Q anesthetic pump in gynecologic oncology: feasibility study of a novel placement technique at an army hospital. Mil Med 2008;173:918-23.
27. Kerr DR, Kohan L. 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 2008;79:174-83. CrossRef
28. Whiteman A, Bajaj S, Hasan M. Novel techniques of local anaesthetic infiltration. Cont Educ Anaesth Crit Care Pain 2011;11:167-71. CrossRef
29. Spreng UJ, Dahl V, Hjall A, Fagerland MW, Ræder J. High-volume local infiltration analgesia combined with intravenous or local ketorolac+morphine compared with epidural analgesia after total knee arthroplasty. Br J Anaesth 2010;105:675-82. CrossRef
30. Andersen LØ, Kristensen BB, Husted H, Otte KS, Kehlet H. Local anesthetics after total knee arthroplasty: intraarticular or extraarticular administration? A randomized, double-blind, placebo-controlled study. Acta Orthop 2008;79:800-5. CrossRef
31. Vendittoli PA, Makinen P, Drolet P, Lavigne M, Fallaha M, Guertin MC, et al. A multimodal analgesia protocol for total knee arthroplasty. A randomized, controlled study. J Bone Joint Surg Am 2006;88:282-9. CrossRef
32. Choi PT, Bhandari M, Scott J, Douketis J. Epidural analgesia for pain relief following hip or knee replacement. Cochrane Database Syst Rev 2003;3:CD003071.
33. Thorsell M, Holst P, Hyldahl HC, Weidenhielm L. Pain control after total knee arthroplasty: a prospective study comparing local infiltration anesthesia and epidural anesthesia. Orthopedics 2010;33:75-80. CrossRef
34. Hynes D, McCarroll M, Hiesse-Provost O. Analgesic efficacy of parenteral paracetamol (propacetamol) and diclofenac in post-operative orthopaedic pain. Acta Anaesthesiol Scand 2006;50:374-81. CrossRef