J Anesth (2007) 21:409–412
DOI 10.1007/s00540-007-0515-0

Journal of
Anesthesia

The analgesic efficacy of two different approaches to the lumbar plexus for patient-controlled analgesia after total knee replacement

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Abstract
This study assessed the efficacy of a patient-controlled regional analgesia technique for either psoas compartment block or femoral nerve block after total knee replacement in 68 patients who were randomly divided into these two groups. All patients received 40 ml of 0.25% bupivacaine via femoral or psoas catheters before general anesthesia, and then, as patient-controlled regional analgesia, 10-ml boluses of 0.125% bupivacaine, with a lockout time of 60 min over 48 h. Pain scores, sensory block, supplemental analgesia, bupivacaine consumption, and side effects were recorded. All measured parameters were comparable in the two groups. Both techniques achieved a good quality of analgesia and satisfaction without any major side effect.

Key words Psoas compartment block · Femoral nerve block · Patient-controlled regional analgesia · Total knee replacement

Introduction

Continuous plexus and peripheral nerve blocks offer the potential benefits of prolonged analgesia with fewer side effects, greater patient satisfaction, and faster functional recovery after surgery than central nerve block and intravenous opioid analgesia [1,2]. The aim of this study was to compare the characteristics and analgesic efficacy of postoperative patient-controlled regional analgesia (PCRA) provided by either a psoas compartment block or a femoral nerve block after total knee replacement (TKR).

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Received: September 6, 2006 / Accepted: February 22, 2007

Patients and methods

After informed consent was obtained and, with institutional approval, 68 adult patients between the ages of 20 and 70 years, American Society of Anesthesiology (ASA) physical status I-III, scheduled for elective unilateral TKR under general anesthesia, were included in this prospective study. The patients were randomly assigned to two groups: group F patients ($n = 34$) had a continuous femoral nerve block, and group P patients ($n = 34$) had a continuous psoas compartment block.

The femoral nerve was identified with a 55-mm insulated needle (Contiplex D; B. Braun, Melsungen, Germany) with the patient in the supine position as described by Winnie et al. [3]. The psoas compartment block was performed with the patient in the lateral decubitus position, with the technique described by Chayen et al. [4]. The lumbar plexus was identified with an insulated Tuohy 18-G, 150-mm-long needle (Contiplex Tuohy Continuous Nerve Block Set; B. Braun Medical, Bethlehem, PA, USA). Catheters were threaded 6–8 cm into the femoral nerve sheath and psoas compartment when contraction of the quadriceps muscle was seen with a stimulus of 0.5 mA or less. Then 40 ml of 0.25% bupivacaine with 1:200 000 epinephrine was injected through the catheter. Sensory blockade was assessed in the distributions of the femoral nerve, the lateral femoral cutaneous nerve, and the obturator nerve 30 min after local anesthetic injection, and then at 6, 24, and 48 h postoperatively by using cold perception. Motor blockade was evaluated by decreased ability to straighten the operative leg against the hand of the examiner at the same intervals. Inadvertent epidural spread was determined bilaterally from T_4 to S_1 dermatomes and recorded as present or absent.

Intraoperative general anesthesia was standardized for the two study groups, and supplemental fentany1 1.5 $\mu g \cdot kg^{-1}$ was administered if necessary. Lornoxicam 8 mg IV was administered at the induction of general

anesthesia, and then three times daily during the first 48 h postoperatively. Approximately 30 min before the end of the surgery, 10 ml of 0.125% bupivacaine was given throught the catheter.

At the end of the operation, the catheters were connected to a patient-controlled analgesia (PCA) pump (APM; Abbott, Chicago, IL, USA) adjusted to deliver PCA boluses of 10 ml of 0.125% bupivacaine with a lockout time of 60 min during the first 48 h postoperatively. Pain intensity was scored using a visual analogue scale (VAS), ranging from 0, no pain to 100, worst pain imaginable. Pain scores at rest were noted at the time (time 0) that each patient regained consciousness in the Post Anesthesia Care Unit (PACU) and again at 6, 24, and 48 h after surgery and daily during physiotherapy for the first 2 postoperative days (PODs). Early rehabilitation included only isometric contraction exercise on POD 1. Knee flexion was begun on POD 2, with manual physical therapy and twice-daily assessments by physical therapists. The goal was 50°–60° flexion on POD 2. The highest VAS scores during physiotherapy were used for analysis. Rescue analgesia was provided with bolus doses of IV tramadol $1 \cdot mg \cdot kg^{-1}$ if the VAS score during rest was 40 or greater, and the tramadol requirement was noted. Supplemental analgesia, bupivacaine consumption, satisfaction scores (0, not satisfied; 100, entirely satisfied) and side effects were recorded in the study period.

Data values are presented as means ± SD or percentages. The Kolmogorov Smirnov test was used to analyze the distribution of the data. The unpaired *t*-test and Mann Whitney-*U* test were used as required. Nominal data were analyzed with the χ^2 test. A value of $P < 0.05$ was considered significant.

Results

The demographic data are presented in Table 1. Two patients in group F and one patient in group P were excluded from the study, as the necessary sensory and motor block was not obtained despite a previous successful catheterization. In group P, one patient had inadvertent epidural spread of the local anesthetic and was also excluded. Pain scores (VAS), satisfaction scores, bupivacaine consumption, and supplemental analgesia were comparable in the two groups (Table 2). The distribution of the sensory blockade and motor blockade as similar in the two groups (Table 3). No side effects, technical problems, or clinical symptoms of local anesthetic toxicity were observed.

Discussion

In this study, both the techniques achieved good quality of analgesia and patient satisfaction during the first 48 h postoperatively. The VAS pain scores were less than 25 at rest and less than 50 during physiotherapy. Patient satisfaction with the overall pain management was high in both groups. Prospective clinical trials support the use of continuous femoral analgesia after TKR [5–7]. Although the safety of continuous infusion has been reported, it may lead to an accumulation of the local anesthetic that is administered in large volumes, and this has a potential risk of toxicity after prolonged periods of infusion [8]. There may be advantages of a

Table 1. Demographic and intraoperative data

	Group F ($n = 32$)	Group P ($n = 32$)
Age (years)	54 ± 19	59 ± 16
Sex (F/M)	28/4	25/7
Weight (kg)	86 ± 22	82 ± 19
ASA (I/II/III)	4/25/3	4/26/2
Intraoperative fentany1 (μg)	78 ± 22	86 ± 28
Duration of the procedure (min)	126 ± 45	132 ± 49

Values are expressed as means ± SD

Table 2. Pain and satisfaction scores, bupivacaine consumption, and supplemental analgesia

	Group F ($n = 32$)	Group P ($n = 32$)
VAS_R		
0 h	19 ± 11 (95% CI, 15–23)	15 ± 14 (95% CI, 11–19)
6 h	23 ± 18 (95% CI, 18–26)	20 ± 18 (95% CI, 14–26)
24 h	15 ± 10 (95% CI, 11–18)	16 ± 11 (95% CI, 11–19)
48 h	9 ± 6 (95% CI, 7–11)	10 ± 7 (95% CI, 7–12)
$VAS_{\text{During physiotherapy POD 1}}$	37 ± 21 (95% CI, 30–45)	34 ± 16 (95% CI, 29–40)
$VAS_{\text{During physiotherapy POD 2}}$	43 ± 24 (95% CI, 34–51)	46 ± 20 (95% CI, 39–54)
Satisfaction	86 ± 14 (95% CI, 81.1–91)	88 ± 21 (95% CI, 80–94.9)
Bupivacaine consumption (ml per 48 h with PCA bolus)	256 ± 49 (95% CI, 238.9–273.9)	248 ± 37 (95% CI, 235–261.8)
Tramadol (mg per 48 h)	57 ± 24 (95% CI, 47.7–65.3)	49 ± 33 (95% CI, 37.2–60.8)

Values are expressed as means ± SD
POD 1, first postoperative day; POD 2, postoperative day 2; PCA, patient-controlled analgesia; cl, confidence interval
R, at rest

Table 3. Sensory blockade

	Group F ($n = 32$)	Group P ($n = 32$)
Femoral nerve		
Preoperative	100 (32)	100 (32)
6 h	97 (31)	100 (32)
24 h	84 (27)	88 (28)
48 h	84 (27)	88 (28)
Lateral femoral cutaneous nerve		
Preoperative	88 (28)	94 (30)
6 h	84 (27)	91 (29)
24 h	78 (25)	81 (26)
48 h	69 (22)	78 (25)
Obturator nerve		
Preoperative	88 (28)	91 (29)
6 h	81 (26)	84 (27)
24 h	56 (18)	66 (21)
48 h	50 (16)	56 (18)

Values are expressed as percentages (n). Statistical analysis was performed with the χ^2 test

bolus technique in terms of the distribution of local anesthetics. Therefore, continuous basal infusion was avoided in the present study and the local anesthetic was given only by PCA boluses. In the few previous reports concerning the use of femoral or psoas compartment block, similar infusion rates have been suggested for both techniques [9,10]. We used the same bolus dose and lockout interval in both groups, taking into account the results of the previous studies.

Kaloul and colleagues [11] compared the efficacy of a continuous posterior lumbar plexus block to that of a continuous three-in-one femoral nerve block in patients undergoing primary TKP, and they achieved similar analgesia with both regional techniques. When similar continuous infusion rates are used, it is not possible to distinguish the differences between the requirements of the local anesthetic for various techniques. Kaloul et al. [11] used a high volume of infusion, 0.2% ropivacaine at $12\,ml \cdot h^{-1}$, in both techniques, resulting in a consumption of 576 ml of the local anesthetic in 48 h. In the present study, in which the patient-controlled bolus technique was used, the local anesthetic consumption was found to be lower than that reported by Kaloul et al. [11] in both groups. Our patients have used 256 ± 49 ml 0.125% bupivacaine in 48 h in group F and 248 ± 37 ml in Group P.

In this study, all the catheters were placed successfully in both techniques. Reported success rates of placing a catheter via the femoral nerve sheath using a peripheral nerve stimulator range from 80% to 100% [5–7,10,12,13]. Limited case series and clinical trials suggest this rate to be 85%–100% during inserting of the catheters by a psoas compartment approach [4,13].

In our study, the motor block and the distribution of analgesia obtained by psoas compartment block or femoral nerve block were similar after administration of the loading dose. Although the obturator nerve has been reported to be blocked better by the psoas compartment approach, we did not find any difference between the groups. A discrepancy between the sensory and motor block can be a result of the high variation in the cutaneous distribution of the obturator nerve, as Bouaziz et al. [14] have reported. During PCRA, the distribution of the sensory block changed with time in both groups. The femoral and lateral femoral cutaneous nerve blocks were well maintained, while the obturator nerve block was more evanescent, particularly at 24 and 48 h after surgery. This can be explained by the lower concentration and volume of the local anesthetic given as PCA boluses than the loading dose administered before surgery. In our study, all patients were able to perform the early rehabilitation program, which included isometric contraction exercise on the first postoperative day. The concentration of the local anesthetic used did not produce a profound motor block that impaired mobilization in the postoperative period.

Epidural diffusion of the local anesthetic is the most frequent problem in a psoas compartment block. The reported incidence of epidural diffusion varies greatly in the literature, from less than 1% to 16% [15–19]. In our study, only one patient in group P experienced inadvertent epidural spread.

Although further studies are needed to investigate the distribution of the lumbar plexus block, PCA doses, lockout intervals, and the necessity for a continuous infusion, we concluded that the femoral nerve block and the psoas compartment block used in this study provided safe and effective analgesia during PCRA.

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