The posterior lumbar plexus (psoas compartment) block and the three-in-one femoral nerve block provide similar postoperative analgesia after total knee replacement

[Le bloc du plexus lombaire par voie postérieure (loge du psoas) et le bloc du nerf fémoral trois-en-un produisent une analgésie similaire après une arthroscopie totale du genou]

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Purpose: To compare the efficacy of a continuous posterior lumbar plexus (PSOAS) block to a continuous three-in-one femoral nerve (FEM) block in patients undergoing primary total knee replacement (TKR).

Methods: Sixty patients were randomly allocated to receive *iv* patient-controlled morphine analgesia (PCA), PCA plus a continuous FEM block with 30 mL ropivacaine 0.5% and epinephrine 1:200,000 bolus followed by an infusion of ropivacaine 0.2% at 12 $mL \cdot hr^{-1}$ for 48 hr, or PCA plus a continuous PSOAS block with the same bolus and infusion regimen as the FEM group. Postoperative morphine consumption, verbal analogue scale pain scores at rest and during physiotherapy, and evidence of sensory and motor blockades were noted.

Results: Both regional techniques significantly reduced 48 hr morphine consumption (FEM 37.3 ± 34.7 mg, $P = 0.0002$; PSOAS 36.1 ± 25.8 mg, $P < 0.0001$) compared to PCA (72.2 ± 26.6 mg). Pain scores at rest, six and 24 hr after TKR were lower in the FEM and PSOAS groups compared to the PCA group ($P < 0.0001$). Although sensory and motor blockades of the obturator nerve were achieved more often in the PSOAS group than in the FEM group ($P < 0.0001$), morphine consumption and pain scores did not differ between the two groups.

Conclusion: Both continuous PSOAS block and continous three-in-one FEM block provided better analgesia than PCA but no differences were seen between the two regional techniques.

Objectif : *Comparer l'efficacité d'un bloc continu du plexus lombaire par voie postérieure (PSOAS) à celle d'un bloc trois-en-un du nerf fémoral (FEM) pour l'analgésie postopératoire des patients subissant une arthroplastie totale du genou (ATG).*

Méthode : *Soixante patients ont été divisés au hasard en trois groupes égaux et ont reçu l'analgésie iv auto-contrôlée (AAC) avec morphine, l'AAC plus un bloc FEM avec 30 mL de ropivacaïne 0,5 % et adrénalinée à 1:200 000 suivi d'une perfusion de ropivacaïne 0,2 % à 12 $mL \cdot h^{-1}$ pour 48 h, ou l'AAC plus un bloc PSOAS continu. La consommation de morphine, le score de douleur par l'échelle verbale analogique (ÉVA) au repos et durant la kinésithérapie, et les blocs sensitifs et moteurs ont été notés.*

Résultats : *Les deux types de bloc, comparés à l'AAC, réduisent la consommation totale (48 h) de morphine (AAC 72,2 ± 26,6 mg; FEM 37,3 ± 34,7 mg, $P = 0,0002$; PSOAS 36,1 ± 25,8 mg, $P < 0,0001$) et les scores de douleur au repos, à six et 24 h après l'ATG ont été plus bas dans les groupes FEM et PSOAS comparés au groupe d'AAC ($P < 0,0001$). Le blocage du nerf obturateur (sensitif et moteur) est plus constant avec le bloc PSOAS qu'avec le bloc FEM ($P < 0,0001$) mais les deux techniques ont un effet similaire sur la consommation de morphine et les ÉVA.*

Conclusion : *Comparativement à l'AAC, les deux blocs continus du plexus lombaire offrent une meilleure analgésie postopératoire mais il n'y a pas de différence entre les deux types de bloc quant à la consommation de morphine et aux ÉVA.*

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IT has been suggested that regional anesthesia provides better postoperative analgesia than *iv* patient-controlled analgesia (PCA) after total knee replacement (TKR).[1–7] It may allow faster rehabilitation as measured by the maximal degree of knee flexion and walking distance obtained in the early postoperative days, length of hospitalization, and total length of rehabilitation.[1–5] Postoperative epidural analgesia is relatively contraindicated since these patients are usually anticoagulated for the prevention of deep venous thrombosis and pulmonary embolism.[8] Thus, many clinicians now rely on a continuous three-in-one femoral nerve (FEM) block to provide postoperative analgesia after TKR.[2–4,6]

The femoral, or anterior, approach to the lumbar plexus is simple and has virtually no risk of major complications; however, postoperative pain scores from patients receiving continuous FEM blocks are higher than those measured in patients receiving continuous epidural analgesia, at least up to four hours after the surgery.[2] Inability of the femoral approach to block the sciatic nerve may explain its decreased efficacy compared to epidural analgesia; however, Allen *et al.* found no benefit from the addition of a single injection sciatic nerve block to a FEM block in patients undergoing TKR.[9] In addition, local anesthetic spread to the obturator nerve, mainly the posterior branch, is almost never achieved with the FEM block.[10] A recent study demonstrated improved postoperative analgesia after TKR with the addition of an obturator nerve block to a combined sciatic and FEM block.[11]

The posterior lumbar plexus (psoas compartment, PSOAS) block has been shown to achieve more consistent blockade of the obturator nerve;[11,12] thus, it may be superior to a FEM block for postoperative analgesia after TKR. The aim of this study was to evaluate the efficacy of continuous PSOAS and continuous FEM blocks for postoperative analgesia after TKR.

Methods

Patient selection and study design

Sixty patients undergoing primary TKR for osteoarthritis, who were 20 to 80 yr of age and American Society of Anesthesiologists (ASA) physical status class I to III, were randomized in blocks of six patients with allocation drawn from an envelope, to receive PCA with morphine (n = 20), PCA plus a continuous FEM block (n = 20), or PCA plus a continuous PSOAS block (n = 20). Patients were excluded if they were allergic to amide local anesthetics, fentanyl, or midazolam; had a history of hepatic or renal failure (serum creatinine > 150 $\mu mol \cdot L^{-1}$); had a contraindication to regional anesthesia (acquired or congenital coagulopathy, systemic or local infection, neurological disease affecting the lower limbs) or the use of PCA (drug dependence, inability to understand the use of the PCA device), or weighed over 110 kg. The local Ethics Committee approved the study protocol and a written informed consent was obtained from each patient.

Regional anesthetic techniques

Patients randomized to receive FEM or PSOAS block underwent regional anesthesia after *iv* sedation with fentanyl 50 to 150 µg and midazolam 1 to 3 mg, disinfection with chlorexidine, sterile draping, and local infiltration with lidocaine 1% or bupivacaine 0.25%. All blocks were performed in a regional anesthetic induction room. In both groups, the FEM was identified using techniques described by Winnie *et al.*[13] For the FEM block, the FEM was identified with an insulated Tuohy 18-gauge, 10.2 cm long needle (CNB 400 Contiplex® B. Braun Medical Inc., Bethlehem, PA, USA) with the patient in supine position.[13] For the PSOAS block, the FEM was identified with an insulated Tuohy 18-gauge, 15.2 cm long needle (CNB 600 Contiplex® B. Braun Medical Inc., Bethlehem, PA, USA) with the patient in the lateral decubitus position (operative side up).

Catheters were introduced when contraction of the quadriceps (patellar elevation) was seen with a stimulus of 0.5 mA or less. If necessary, preservative-free 0.9% saline was injected through the needle to facilitate the catheter insertion. Catheters were then fixed and a test dose of 3 mL of ropivacaine 0.5% with epinephrine 1:200,000 was injected followed by the rest of the solution (30 mL total dose) if no evidence of local anesthetic toxicity occurred within three minutes after the injection of the test dose. An infusion of ropivacaine 0.2% was immediately started, after the loading dose, at 12 $mL \cdot hr^{-1}$ for 48 hr. The volume of saline used to insert the catheter and the duration of the procedure (time elapsed from insertion of the needle through the skin to its withdrawal after the catheter insertion) were noted.

Evidence of sensory (decreased perception to pinprick or ice over anterior aspect of the thigh) and motor (decreased ability to straighten the operative leg against the hand of the examiner) blockades of the FEM was tested every five minutes until the presence of either sensory or motor blockade appeared. Onset time (time between the end of the bolus injection and blockade) was noted and the patient was then transferred to the operating room.

Perioperative management and follow-up

All patients received a spinal anesthetic with 12.5 to 15 mg of isobaric bupivacaine 0.5% and 10 to 15 µg

of fentanyl as well as rectal indomethacin 100 mg twice daily for 48 hr after surgery. Intravenous PCA was provided by morphine 1 mg infused over two minutes with a five-minute lockout period. The study interventions were maintained for 48 hr. Subsequent analgesia was provided by *iv* PCA or oral analgesia (oxycodone or a combination of acetaminophen and codeine) as decided by the attending anesthesiologist.

Outcomes

The primary outcome of this study was 48 hr postoperative morphine consumption, which was assessed at six-hour intervals. A number of secondary outcomes were also assessed. Postoperative pain intensity was scored using a 0 to 100 verbal analogue scale (VAS). Pain scores at rest were noted at six, 24, and 48 hr after surgery and daily during physiotherapy for the first two postoperative days. The higher of the two VAS scores of pain during physiotherapy was used for analysis. Evidence of motor blockade of the femoral and obturator nerves were also assessed at six, 24 and 48 hr. Presence of blockade was defined as weakness in knee flexion against resistance (FEM) or weakness in hip adduction, with knee flexed, against resistance (obturator nerve). Sensory blockade of the obturator nerve was assessed at the internal medial aspect of the thigh. Patients were asked to rate their satisfaction, on a scale from 0 to 100 (0 = unsatisfied, 100 = very satisfied), regarding the ease of the catheter insertion and regarding the overall pain management. All data were collected by a clinical research assistant, who was unblinded to the technique used.

Statistical analysis

Based on the data from Singelyn *et al.* (67 ± 26 mg), 20 patients per group would detect a 30% reduction in morphine consumption, relative to the PCA group, during the first 24 hr with a 5% one-tailed type I error rate and 80% power.[2] Statview (SAS Institute Inc, Cary, NC, USA) and Prism 3.0 (GraphPad Software Inc, San Diego, CA, USA) were used for statistical analysis. Continuous data with normal distribution were analyzed with unpaired t tests, two-way analysis of variance (ANOVA), or repeated measures of ANOVA, depending on the number of groups and the frequency of measurement. Continuous data with non-normal distribution and ordinal data were analyzed with a Mann-Whitney, Kruskall Wallis, or Friedman analysis where appropriate. Statistically significant results from comparisons of multiple (> 2) groups or repeated measures were followed by *post hoc* analysis with the Student-Newmann-Keuls test. Nominal data were analyzed by a Chi squared test or the Fisher exact test. A P value < 0.05 was considered statistically significant for comparisons between two groups or ANOVA. Bonferroni or Yates correction were used when multiple comparisons were made and a P value < 0.017 was considered statistically significant.

TABLE I Demographic data

	PCA (n = 20)	*FEM (n = 20)*	*PSOAS (n = 20)*
Age (yr)	69.5 ± 4.9	66.7 ± 12.1	68.9 ± 6.9
Sex distribution (F/M)	13/7	12/8	13/7
Weight (kg)	81.2 ± 17.1	76.9 ± 15.9	81.2 ± 13.2
Height (cm)	162.3 ± 8.3	160.2 ± 9.3	161.6 ± 9.0
ASA physical status (I/II/III)	2/16/2	1/18/1	1/16/3

FEM = continuous three-in-one femoral nerve block; PCA = patient-controlled analgesia; PSOAS = continuous posterior lumbar (psoas compartment) plexus block. Age, weight, and height are expressed as mean ± SD.

TABLE II Information related to the regional anesthetic technique

	FEM (n = 20)	*PSOAS (n = 20)*
Medications used		
Midazolam (mg)	1.2 ± 0.5	1.3 ± 0.5
Fentanyl (μg)	53.8 ± 32.7	60.7 ± 27.8
Local infiltration (mL)	3.1 ± 2.2	5.2 ± 2.1*
0.9% saline to facilitate catheter insertion (mL)	2.1 ± 2.8	3.5 ± 6.3
Procedure time (min)	16.6 ± 6.0	17.5 ± 8.9
Onset time (min)	6.8 ± 3.0	6.2 ± 3.0
Patient satisfaction†	88.2 ± 17.7	90.5 ± 10.9

FEM = continuous three-in-one femoral nerve block; PSOAS = continuous posterior lumbar plexus (psoas compartment) block. All values are expressed as mean ± SD. *P = 0.004, †Concerning the ease of catheter insertion, 0 = unsatisfied and 100 = very satisfied.

Results

The three groups were similar regarding age, gender distribution, weight, and ASA physical status (Table I). A higher mean dose of local anesthetic was used for local infiltration before needle insertion in the PSOAS group (5.2 ± 2.1 mL) compared to the FEM group (3.1 ± 2.1 mL, P = 0.004). However, the two groups did not differ regarding the amount of sedation and saline used, the procedure and onset times, or the patient satisfaction regarding the technique (Table II).

Continuous FEM block and continuous PSOAS block reduced 48 hr morphine consumption by 48% (P = 0.0002) and 50% (P < 0.0001) respectively compared to PCA (Figure 1). The difference was statistically significant for comparisons of PCA *vs* FEM or

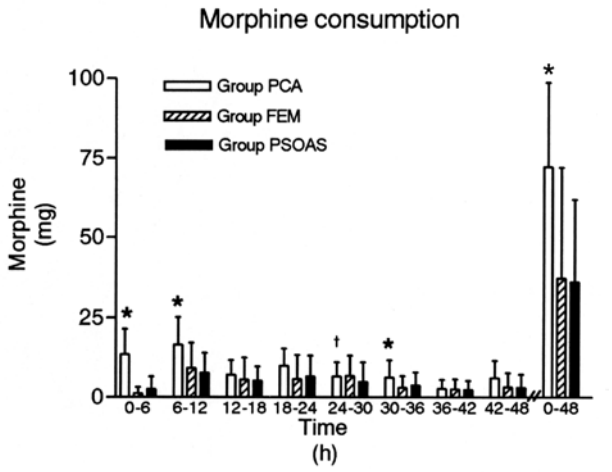

FIGURE 1 Bar graph of *iv* morphine consumption by group and time during the first 48 hr after surgery. Group PCA = patient-controlled analgesia; group FEM = continuous three-in-one femoral nerve block plus PCA; group PSOAS = continuous posterior lumbar plexus (psoas compartment) block plus PCA. Values are expressed as mean ± standard deviation. * and ‡ Statistically significant differences between group PCA and group FEM and between group PCA and group PSOAS. †Statistically significant difference between group PCA and group PSOAS.

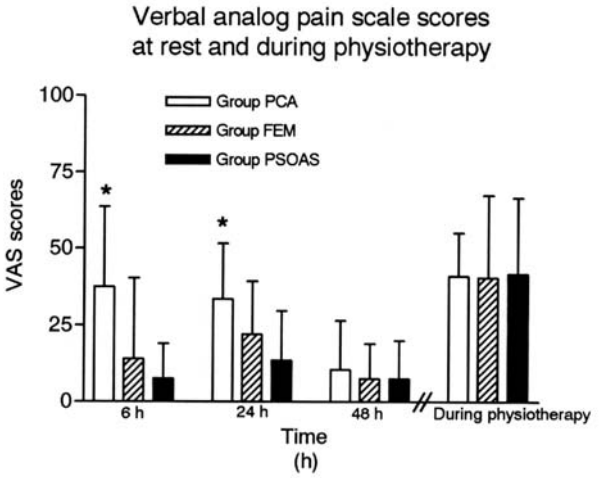

FIGURE 2 Bar graph of verbal analogue scale scores for pain intensity at rest and during physiotherapy by group. Group PCA = patient-controlled analgesia; group FEM = continuous three-in-one femoral nerve block plus PCA; group PSOAS = continuous posterior lumbar plexus (psoas compartment) block plus PCA. Values are expressed as mean ± standard deviation. *Statistically significant differences between group PCA and group FEM and between group PCA and group PSOAS.

PSOAS blockade at the zero to six hour, six to 12 hr, and 30–36 hr intervals and for the comparison of PCA *vs* PSOAS blockade for the 24–30 hr interval (Figure 1). Patients in the PSOAS group consumed less morphine (1.3 mg) than patients in the FEM group over 48 hr. The difference was not statistically or clinically significant. The power to detect a 30% decrease in morphine consumption between the two regional anesthetic groups was low (10%) but 125 patients per group would have been necessary to achieve 80% power with a 5% one-sided type I error rate.

Pain scores at rest were also significantly reduced by the use of a local anesthetic infusion ($P < 0.0001$, Figure 2). The scores were significantly lower for groups FEM and PSOAS compared to group PCA at six and 24 hr but did not differ between group PSOAS and group FEM. Pain scores during physiotherapy did not differ between the three study groups (PCA 41.1 ± 14.1; FEM 40.6 ± 26.8; PSOAS 41.8 ± 24.8; Figure 3). Nine, seven, and six patients in the PCA, FEM, and PSOAS groups respectively had VAS scores of 50 or higher during physiotherapy at one of the two assessments.

Sensory and motor blockades of the obturator nerve were achieved more frequently in the PSOAS group than in the FEM group ($P < 0.0001$). The difference was significant at six hours for motor blockade ($P = 0.004$, Figure 3) and at 24 hr for sensory blockade ($P = 0.02$). At six hours, 90% (18/20) of the patients in the PSOAS group had evidence of motor blockade of the obturator nerve compared to 47% (9/19) of the patients in the FEM group.

Patient satisfaction with the overall pain management was high. There were no significant differences between the groups (PCA 86.5 ± 10.3; FEM 94.8 ± 8.2; PSOAS 93.0 ± 7.8).

Discussion

Morphine consumption in the first 48 hr was almost the same for both techniques of regional anesthesia (Figure 1). The posterior approach to the lumbar plexus block allowed extension of the block in the obturator territory in a significantly higher percentage of patients than the three-in-one approach. This was well illustrated by the percentage of patients in whom a significant degree of motor blockade could be detected at six hours (Figure 3). The difference in sensory blockade of the obturator nerve was less striking, at least at six hours, but these results were not unexpected. Recently, Bouaziz *et al.* demonstrated that the cutaneous distrib-

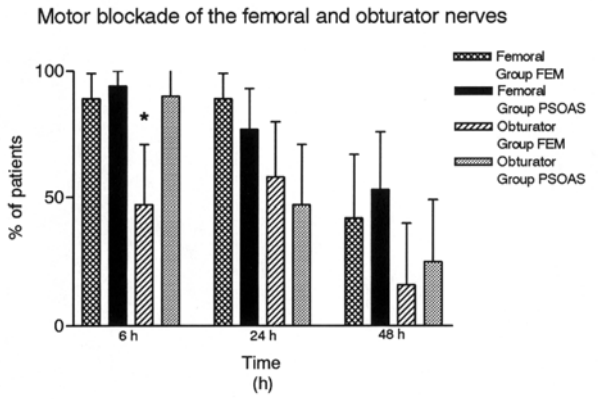

FIGURE 3 Bar graph of the percentage of patients with evidence of motor blockade by group and time. Group FEM = continuous three-in-one femoral nerve block plus patient-controlled analgesia; group PSOAS = continuous posterior lumbar plexus (psoas compartment) block plus patient-controlled analgesia. Values are expressed as percentages ± 95% confidence interval. **P* = 0.004 for the comparison between group FEM and group PSOAS with regards to obturator motor nerve blockade.

ution of the obturator nerve is not only highly variable but may even be incomplete or totally absent.[14] In 57% of their patients, they could not demonstrate any cutaneous contribution of the obturator nerve. In 23% of the cases, a partial cutaneous innervation at the superior aspect of the popliteal fossa was found and for the remaining 20%, obturator nerve blockade resulted in sensory deficit at the medial aspect of the thigh. According to these authors, sensory blockade at the inner part of the thigh was more likely to be from FEM blockade and they concluded that the only way to evaluate obturator nerve blockade was an assessment of hip adductor strength.

The questions now are whether or not the obturator nerve has a sensory component inside the knee in all patients and does obturator nerve blockade have a role to play in the postoperative analgesia of patients undergoing TKR. The study from McNamee *et al.* suggested that obturator nerve blockade is important;[11] however, despite more consistent blockade of the obturator nerve with the PSOAS block, we could not demonstrate any difference between a continuous PSOAS block and a continuous FEM block, at least in terms of 48 hr morphine consumption and VAS pain scores after TKR. These results suggest that the obturator nerve does not contribute significantly to the postoperative pain of patients undergoing TKR. As the posterior approach has been associated with reports of serious adverse complications (total spinal anesthesia, acute local anesthetic toxicity, and renal subcapsular, *im* (psoas) and retroperitoneal hematomas), it may not offer any advantages over the anterior approach.[15–19]

Pain scores during physiotherapy for the first 48 hr were similar in the three groups (Figure 2) and were within the range (36 ± 11) reported by others at 24 hr with the use of a continuous FEM block after TKR.[2] However, we were unable to confirm Singelyn's observation that a continuous FEM block offers better analgesia than *iv* PCA during physiotherapy.[2] Although the local anesthetic used in the present study (ropivacaine 0.2% at 12 mL·hr^{-1}) differed from the one used by Singelyn *et al.* (bupivacaine 0.125% at 10 mL·hr^{-1}), both regimens were roughly equivalent, considering a two-third potency for ropivacaine compared to bupivacaine.[2,20] In their study, Singelyn *et al.* added clonidine 1 μg·mL^{-1} (or 240 μg·day^{-1}) and sufentanil (0.1 μg·mL^{-1} or 24 μg·day^{-1}) to their local anesthetic infusion. When added to a peripheral nerve block, clonidine, a pure specific α_2-agonist, reduces the onset time of sensory blockade, extends the field of adequate analgesia, decreases the use of supplementary *iv* anesthetic agents during surgery, and produces a dose-dependent prolongation of postoperative analgesia.[21] These benefits need to be weighed against potentially serious side effects since clonidine 30 to 300 μg also induce sedation and decrease arterial blood pressure (by as much as 22.5%) in a dose dependent fashion.[21] Moreover, patients who receive a dose of clonidine of 300 μg as an adjunct to local anesthetics in a peripheral nerve block may have episodes of low oxyhemoglobin levels (< 90%).[21] Thus, the supplemental use of clonidine to local anesthetics in an aged population coming for a procedure with potential for significant postoperative blood losses, such as the one that comes from TKR, warrants serious precautions and probably should not be used routinely in that specific situation.[22]

In this study, continuous FEM block was a useful postoperative analgesic modality: patients had lower pain scores at rest during the first 24-hr after surgery and decreased morphine consumption, an appreciable effect in the elderly. On the other hand, morphine was still required and pain relief during physiotherapy was quite disappointing. Other investigators have also mentioned that FEM or PSOAS blockade cannot be used as the sole analgesic modality after TKR. Some are now adding a sciatic nerve block either as a single injection or as a continuous infusion to the continuous three-in-one block.[4,23] The efficacy of this practice requires further evaluation.

Finally, do patients undergoing TKR really need a catheter inserted? If yes, how long should the catheter be maintained? Catheter insertions require expensive specialized equipment and additional expertise and are more time consuming than single injections. Furthermore, maintenance of a catheter for a duration of 48 hr may increase the risks of infection and, depending on the rate and concentration of the local anesthetic used, may result in local anesthetic toxicity.[24,25] The first question was addressed in a study that compared a control group without regional anesthesia, a group with a single-shot FEM block, and a group with a continuous FEM block.[26] Compared to the control group, a reduction in dynamic VAS pain scores was seen in the groups with FEM blockade only in the recovery room. There was no detectable difference between the nerve blockade groups for 72 hr pain scores at rest or with motion or 48 hr morphine consumption. However, the sample size was small (33 patients), which may have led to a falsely negative result. Moreover, one could argue that the volumes of local anesthetic administered (bupivicaine 0.125% 20 mL bolus followed by an infusion at 6 $mL \cdot hr^{-1}$) were inadequate. In this study, despite the high volumes of local anesthetic, there was no improvement in pain scores during physiotherapy and pain scores at rest were improved only in the first 24 hr (Figure 2), while morphine consumption was similar in the three groups after 36 hr with very few clinically significant differences after 12 hr (Figure 1). Data from other authors favour single injection since reduction of morphine consumption up to 48 hr, decrease in VAS pain score up to 24 hr, faster ambulation, and shorter length of hospital stay have been reported with single FEM injections of 30 or 40 mL of bupivacaine 0.25%, although these studies did not compare continuous to single-shot blocks per se.[5,7] One can reasonably conclude that a FEM block improves analgesia and facilitates rehabilitation but that the real benefits of a continuous infusion need further evaluation. From the literature available to date, the maintenance of a catheter for longer than 36 hr probably increases the risks for the patient without any clearly demonstrable benefit over *iv* PCA.[24,25]

In conclusion, no differences in analgesia were seen between continuous PSOAS (psoas compartment) blockade and continuous three-in-one FEM blockade for postoperative pain relief in patients undergoing TKR. As the former has been associated with severe complications, the latter may be the regional anesthetic technique of choice in patients undergoing TKR.

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References

1 *Mahoney OM, Noble PC, Davidson J, Tullos HS.* The effect of continuous epidural analgesia on postoperative pain, rehabilitation, and duration of hospitalization in total knee arthroplasty. Clin Orthop 1990; 260: 30–7.

2 *Singelyn FJ, Deyaert M, Joris D, Pendeville ES, Gouverneur JM.* Effects of intravenous patient-controlled analgesia with morphine, continuous epidural analgesia, and continuous three-in-one block on postoperative pain and knee rehabilitation after unilateral total knee arthroplasty. Anesth Analg 1998; 87: 88–92.

3 *Capdevila X, Barthelet Y, Biboulet P, Ryckwaert Y, Rubenovitch J, d'Athis F.* Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. Anesthesiology 1999; 91: 8–15.

4 *Chelly JE, Greger J, Gebhard R, et al.* Continuous femoral blocks improve recovery and outcome of patients undergoing total knee arthroplasty. J Arthroplasty 2001; 16: 436–45.

5 *Wang H, Boctor B, Verner J.* The effect of single-injection femoral nerve block on rehabilitation and length of hospital stay after total knee replacement. Reg Anesth Pain Med 2002; 27: 139–44.

6 *Edwards ND, Wright EM.* Continuous low-dose 3-in-1 nerve blockade for postoperative pain relief after total knee replacement. Anesth Analg 1992; 75: 265–7.

7 *Ng HP, Cheong KF, Lim A, Lim J, Puhaindran ME.* Intraoperative single-shot "3-in-1" femoral nerve block with ropivacaine 0.25%, ropivacaine 0.5% or bupivacaine 0.25% provides comparable 48-hr analgesia after unilateral total knee replacement. Can J Anesth 2001; 48: 1102–8.

8 *American Society of Regional Anesthesia and Pain Medicine.* Regional anesthesia in the anticoagulated patient – defining the risks. 2002 [cited 17 May 2003]. Available from: URL: http://www.asra.com/items_of_interest/consensus_statements/index.iphtml.

9 *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.

10 *Marhofer P, Nasel C, Sitzwohl C, Kapral S.* Magnetic resonance imaging of the distribution of local anesthetic during the three-in-one block. Anesth Analg 2000; 90: 119–24.

11 *McNamee DA, Parks L, Milligan KR.* Post-operative analgesia following total knee replacement: an evalua-

tion of the addition of an obturator nerve block to combined femoral and sciatic nerve block. Acta Anaesthesiol Scand 2002; 46: 95–9.
12 *Parkinson SK, Mueller JB, Little WL, Bailey SL.* Extent of blockade with various approaches to the lumbar plexus. Anesth Analg 1989; 68: 243–8.
13 *Winnie AP, Ramamurthy S, Durrani Z, Radonjic R.* Plexus blocks for lower extremity surgery. new answers to old problems. Anesthesiology 1974; 1: 11–6.
14 *Bouaziz H, Vial F, Jochum D, et al.* An evaluation of the cutaneous distribution after obturator nerve block. Anesth Analg 2002; 94: 445–9.
15 *Gentili M, Aveline C, Bonnet F.* Total spinal anesthesia after posterior lumbar plexus block (French). Ann Fr Anesth Réanim 1998; 17: 740–2.
16 *Pham-Dang C, Beaumont S, Floch H, Bodin J, Winer A, Pinaud M.* Acute toxic accident following lumbar plexus block with bupivacaine (French). Ann Fr Anesth Réanim 2000; 19: 356–9.
17 *Klein SM, D'Ercole F, Greengrass RA, Warner DS.* Enoxaparin associated with psoas hematoma and lumbar plexopathy after lumbar plexus block. Anesthesiology 1997; 87: 1576–9.
18 *Aida S, Takahashi H, Shimoji K.* Renal subcapsular hematoma after lumbar plexus block. Anesthesiology 1996; 84: 452–5.
19 *Weller RS, Gerancher JC, Crews JC, Wade KL.* Extensive retroperitoneal hematoma without neurologic deficit in two patients who underwent lumbar plexus block and were later anticoagulated. Anesthesiology 2003; 98: 581–5.
20 *Capogna G, Celleno D, Fusco P, Lyons G, Columb M.* Relative potencies of bupivacaine and ropivicaine for analgesia in labour. Br J Anaesth 1999; 82: 371–3.
21 *Bernard JM, Macaire P.* Dose-range effects of clonidine added to lidocaine for brachial plexus block. Anesthesiology 1997; 87: 277–84.
22 *Hiippala S, Strid L, Wennerstrand M, et al.* Tranexamic acid (Cyklokapron) reduces perioperative blood loss associated with total knee arthroplasty. Br J Anaesth 1995; 74: 534–7.
23 Synthèse: quels blocs tronculaires du membre pelvien choisir? *In:* Gaertner E, Choquet O, Macaire P, Zetlaoui PJ (Eds.). Anesthésie Régionale : Anesthésie Tronculaire et Plexique de L'adulte. Reuil-Malmaison: Arnette; 2001: 191.
24 *Bernard N, Pirat P, Branchereau S, Gaertner E, Capdevila X.* Continuous peripheral nerve blocks in 1416 patients : a prospective multicenter study measuring incidences and characteristics of infectious adverse events. Anesthesiology 2002; 96: 882 (abstract).
25 *Kaloul I, Guay J, Côté C, Halwagi A, Varin F.* Ropivacaine plasma concentrations are similar during continuous lumbar plexus blockade: using the anterior three-in-one and the posterior psoas compartment techniques? Can J Anesth 2004; 51: 52–6.
26 *Hirst GC, Lang SA, Dust WN, Cassidy JD, Yip RW.* Femoral nerve block. Single injection versus continuous infusion for total knee arthroplasty. Reg Anesth 1996; 21: 292–7.