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# Anaesthesia for total knee arthroplasty: efficacy of single-injection or continuous lumbar plexus associated with sciatic nerve blocks – A randomized controlled study

L. FRASSANITO, A. VERGARI, A. MESSINA, S. PITONI, C. PUGLISI, A. CHIERICHINI

Emergency and Admittance Department, Catholic University of Sacred Heart, Rome (Italy)

**Abstract. – Total knee arthroplasty (TKA) often results in marked postoperative pain. We compared in a randomized controlled study tramadol consumption, postoperative pain and patient satisfaction after primary TKA in patients who received a single injection lumbar plexus and sciatic nerve blocks or a continuous lumbar plexus and sciatic nerve blocks.**

**Forty-four patients scheduled for unilateral total knee arthroplasty were allocated to the single shot group (group A) or to the catheter group (group B). All patients (in both groups) reported being satisfied with their anaesthetic management. Although pain scores and tramadol consumption appeared lower in the active infusion group, the differences did not reach statistical significance.**

**This study confirms that either single injection or continuous infusion of Ropivacaine in lumbar plexus provides reliable and long-acting anaesthesia and analgesia.**

*Key Words:*

Knee arthroplasty, Ropivacaine, Lumbar plexus block, Sciatic nerve block, Postoperative pain.

## Introduction

Total knee arthroplasty (TKA) is a commonly performed surgical procedure, which despite the beneficial long-term effects, often results in marked postoperative pain. Patients are usually elderly with comorbid diseases and it is important to choose an anaesthetic and analgesic regimen that will minimise side effects as well as providing suitable pain relief. Optimal peri-operative analgesia will enhance functional recovery, including timely recovery of knee mobility, and reduce postoperative morbidity[1,2]. Current approaches used in the treatment of this pain include systemic opiates, epidural analgesia and peripheral nerve blocks[1-5]. Several reports showed that continuous perineural infusion of local anaesthetics (LA) using a catheter technique can provide equal or superior analgesia when compared with epidural infusion or patient-controlled analgesia (PCA) with morphine but with less opioids-related and autonomic adverse effects, less motor block, fewer serious neurological complications and more rapid recovery[1,2,4].

However, it is not clear from the existing evidence, whether the infusion itself is required for this beneficial effects or single-injection nerve block would be as effective. Moreover, few reports investigated the use of lumbar plexus block associated to sciatic nerve block as unique tool of anaesthesia for TKA[6,7].

We have conducted a randomized controlled trial comparing tramadol consumption, pain and patient satisfaction after primary TKA in patients who received a single injection lumbar plexus and sciatic nerve blocks or a lumbar plexus and sciatic nerve blocks followed by a continuous lumbar plexus infusion of ropivacaine 0,2%.

## Materials and Methods

Approval for the study was obtained from the local research Ethics Committee. After obtaining written informed consent, 44 consecutive patients affected by osteoarthritis scheduled for primary unilateral bicompartmental-cemented total knee arthroplasty by a traditional approach were enrolled in the study. Exclusion criteria were mor-

*Corresponding Author*: Luciano Frassanito, MD; e-mail: lucfras75@hotmail.com

bid obesity (more than twice ideal b. w.), contraindication to regional anesthesia, American Society of Anesthesiologists status (ASA) IV or V, peripheral neuropathy, chronic opioid use, and allergy to local anaesthetics, acetaminophen or tramadol. After attachment of electrocardiogram monitoring, pulse oximetry, and noninvasive blood pressure monitors, intravenous (IV) access was obtained and all patients received midazolam 2 or 3 mg plus fentanyl 50 mcg as an intravenous premedication approximately 5 minutes before anaesthesia, titrated to effect to produce sedation while maintaining verbal contact. IV fluids were commenced using a crystalloid solution (5 ml/kg). An LA solution of 50 mL 0.6% ropivacaine was prepared.

Patients were allocated to the single shot group (group A) or to the catheter group (continuous perineural infusion, group B) using a sealed envelope that had been prepared before the study in conjunction with a computer-generated randomization list.

The lumbar plexus was identified with the patient in the lateral position and the operative side up, as described by Chayen et al[8]. After local infiltration with lidocaine 2% 4 ml, the block was performed by one of the Authors using a 12-cm 19.5-G short-bevel insulated needle (Polyplex C 120 K catheter set, Polymedic, Temena, France) connected to a nerve stimulator (Stimuplex, Braun, Sheffield, UK) with a stimulating frequency of 2 Hz and a pulse width of 0.1 millisecond. Once quadriceps contraction with patellar movement could be elicited at a stimulating current of 0.5 mA and after careful aspiration to rule out blood or cerebrospinal fluid, 30 mL of the LA solution was injected slowly in divided doses over at least 1 minute. The injection was stopped and the needle repositioned if the patient complained of pain during injection.

In group B a 50-cm 21-G catheter with a single end orifice was then passed through the needle and advanced about 5 cm beyond the needle tip, before the needle was removed and the catheter secured to the skin using a LOCKiT fixation device (Portex Ltd, Hythe, UK).

The sciatic nerve block was performed using the landmarks described by Labat[9]: using a 10-cm 22-G insulated needle connected to a nerve stimulator. Once plantar flexion of the foot was elicited at a current of 0.5 mA, 15 mL of the LA solution was injected. The time and the difficulty to perform each block was recorded, along with a rating of the ease of performing each block on a subjective 5-point scale (1: very easy, 2: easy, 3: average, 4: difficult, 5: very difficult). The average time to obtain an adequate block was collected. The patients were checked to determine adequacy of anaesthesia before the beginning of surgery. Once a complete block could be shown, they were transferred to the operating room. Multiparametric monitoring and IV infusion were continued, and in case of intraoperative discomfort IV remifentanil infusion were started as needed.

Immediately postoperatively, in group B the LA infusion solution (ropivacaine 0.2%) was connected to the lumbar plexus catheter via a bacterial filter and after negative aspiration was infused continuously at 10 mL/h for 48 hours using an elastomeric pump (Accufuser 275, CME McKinley, UK).

All patients were prescribed regular analgesia, comprising acetaminophen 1 g i.v. four times daily and i.v. tramadol 100 mg up to 400 mg every 24 h in case of inadequate analgesia (VAS score >40). All patients were also prescribed ondansetron 4 mg as required for nausea or vomiting. Subcutaneous enoxaparin 4000 I.U. daily was prescribed as deep venous thrombosis prophylaxis.

Patients were assessed in the postanaesthetic care unit; on arrival in the ward; and at 6, 12, 24, 36, 48, and 72 hours after the start of surgery. Recordings made at these times included total volume of tramadol required, visual analog pain scores from 0 (no pain) to 10 (worst pain imaginable) both at rest and on flexion of the operated knee, nausea (on a 4-point scale: 0, no nausea or vomiting; 1, nausea no vomiting; 2, vomiting; 3, persistent vomiting), motor power in the operated limb using the Bromage scale[10] and ambulation. The infusion was stopped after 48 hours and the catheter was removed. Patients received regular intermittent physiotherapy from day 3 and were encouraged to exercise and walk with assistance as early as possible, pain and motor power allowing. By day 4, patients were encouraged to walk without assistance and to attempt stairs by day 5. Patients' progress was recorded by the physiotherapists, nurses, and medical staff and was assessed for suitability for discharge from day 4.

The primary endpoint for the study was to determine the success rate for lumbar plexus block in providing adequate anesthesia for TKA. Secondary endpoints were visual analog pain scores, tramadol required, time to ambulation, nausea and vomiting, antiemetic requirements.

Data were expressed as mean ± SD, and were analyzed using Students t test or, where applicable, two-way analysis of variance (ANOVA) for repeated measures with time and treatment as the 2 factors. Post hoc comparisons were performed by Bonferroni's test. Block difficulty only was expressed as median and interquartile range and analyzed using the Mann-Whitney U test. Statistical analysis and calculation were performed with a personal computer and with GraphPad statistical software. Statistical significance for all test was a *P* value <0.05.

## Results

Forty-four patients were consented for the study. They were allocated to a group during surgery. No complication was recorded during anaesthetic procedures.

Patient characteristics were similar between the 2 groups (Table I), with no statistically significant differences.

In all patients the blocks were easily performed, and there were no case of difficulty index >2. The mean time to perform the block was similar in the two groups: mean value 10.9 min in group A, 11.3 min in group B.

The density of sensitive and motor block in the operated leg was also comparable between the groups.

In 4 patients (8.7%), 2 in group A and 2 in group B, a bilateral sensitive block was checked. In one of this case was associated hypotension (systolic arterial pressure <90 mmHg), treated with ephedrine 4 mg.

Eight patients (18%), 3 in group A and 5 in group B, required additional intraoperatory analgesia, and a remifentanil infusion at 0.05 mcg/kg/min was started. However, in no patient was necessary general anaesthesia or ventilatory support.

There were no significant differences in the incidence of nausea or requirement for antiemetics between the groups.

There were no adverse effects noted in relation to the infusions. In particular, there was no evidence of postoperative hypotension or sedation. All patients (in both groups) reported being satisfied with their anaesthetic management and would be happy to receive the same technique again.

Although pain scores appeared lower in the active infusion group, the differences did not reach statistical significance (Figure 1). Total tramadol consumption was higher in group A (mean value 236 ± 155) than group B (185 ± 101). No significant difference was found between these different therapeutic strategies (F=3.45, *P*=0.06). On the contrary, ANOVA showed a significant effect of time (F=39.6, *P*<0.0001) as well as a significant treatment-by-time interaction (F=5.05, *P*=0.0006).

## Discussion

In this randomized, controlled study, our data show that the single-injection LPB block is effective as the continuous infusion of LA trough a perineural catheter in reducing tramadol consumption after TKA.

Total knee arthroplasty is a major orthopaedic procedure, commonly performed in patients with

**Table I.** Patient characteristics (mean value ± SD).

| | | |
|---|---|---|
| Age (years) | 69.3 ± 9.9 | 64.9 ± 7.7 |
| Weight (kg) | 72.8 ± 10.3 | 78.9 ± 7.9 |
| ASA* | 2.18 ± 0.7 | 1.8 ± 0.37 |
| Duration of surgery (min) | 127 ± 15 | 130 ± 17 |
| Tramadol consumption (mg) | 236 ± 155 | 185 ± 101 |
| Time of esecution (min) | 10.9 ± 6.1 | 11.3 ± 1.8 |
| Onset time (min) | 21.1 ± 10.3 | 14.28 ± 4.4 |
| Block difficulty (median) | 2 (1-2) | 1 (1-2) |
| Nausea (incidence) | 6 (27%) | 4 (18%) |
| Vomiting (incidence) | 3 (13%) | 1 (4%) |

ASA: American Society of Anesthesiologists physical status.

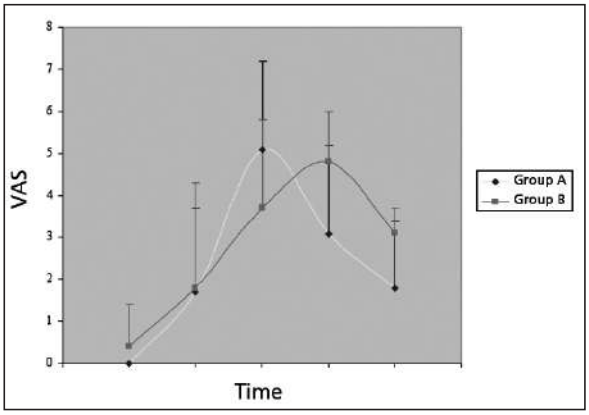


**Figure 1.** Postoperative pain (VAS) trend during first 48 h.

degenerative disease of the knee joint and can relieve disabling joint pain, restore mobility, and improve quality of life. Despite the beneficial long-term effects, the procedure is associated with intense early postoperative pain, and effective analgesia is paramount. Patients are usually elderly with comorbid diseases and it is important to choose an anaesthetic and analgesic regimen that will minimise side effects as well as providing suitable pain relief[11].

Optimal peri-operative analgesia will enhance functional recovery, including timely recovery of knee mobility, and reduce postoperative morbidity. Anaesthesiologic tools have to assure the reduction of all the collateral effects, which could exacerbate preexisting diseases and an effective post-operative analgesia. An effective intra and post-operative analgesia improves the functional recovery and the articular motility and reduces the postoperative morbidity[1].

Several reports demonstrated the importance of regional anesthesia to ensure better postoperative analgesia, lower neuroendocrine response to the surgical stress coupled with a reduced sensibilization of central nervous system and muscle spasm reflex to pain. This peculiar condition is essential to allow a rapid mobilization of the knee, reducing the postoperative hospital stay and the collateral effects of opiates intake (such as vomiting and nausea)[1,2,12-15].

Neuraxial block has been the first kind of regional anestesia used for the lower limb because of the undeniable benefit of an excellent intra and postoperative anesthesia achievable with a single puncture instead of multiple punctures requested for single nerve blocks. Nevertheless, the current extensive use of low molecular weight heparine (LMWH) for the prevention of deep venous thrombosis and pulmonary thromboembolism, linked with the recent availability of perineural catheters for continuous peripheral blocks, has led to a new regard to the lower limb blocks[16,17].

A recent meta-analyses about the anaesthesia for major orthopaedic surgical treatment of the knee, concludes the peripheral blocks of the lower limb ensure an excellent postoperative analgesia, as effective as the analgesia achievable with a peridural infusion, with less collateral effects, such as hypotension, urinary retention, nausea and itch[18].

The most investigated peripheral blocking approaches for knee surgery are the paravascular femoral nerve block[19] and the lumbar plexus block[8,20].

Several reports during the last few years compared femoral nerve block versus lumbar plexus block for postoperative pain treatment after total knee replacement. Many Authors pointed out the same analgesic efficacy comparing the continuous lumbar plexus block with the continuous femoral block, both coupled or not with sciatic nerve block[21-23].

Nevertheless, lumbar plexus block is an effective approach to ensure a good anaesthesia to all the branches of the plexus (femoral nerve, obturator nerve, femorocutaneous nerve), comparing with inguinal paravascular approach[24].

Anyway, some studies investigated the relevance of the effective block of the obturator nerve for postoperative analgesia, and demonstrated that it is quite small[22,25].

Some aspects are still not well recognized. First, there's still a slight evidence about the efficacy of the lumbar plexus block, coupled with sciatic nerve block, as single intraoperative anaesthetic choice[6,7]. Most of the studies, in fact, just analyzed the efficacy of the lumbar plexus block coupled with a general or a spinal anesthesia during the surgical intervention[22,23,25,26]. Results of our study showed an effective and satisfying anaesthesia in 82% of the patients. An infusion of remifentanil 0.05 mcg/kg/min was effective to control intraoperative discomfort in the others. This result appears very important in order to reduce collateral effects of spinal anaesthesia (such as urinary retention, hypotension, spinal hematoma) and general anaesthesia expecially in patients with coexisting morbidities.

Moreover, there's not a general agreement about the real need of a continuous block of the lumbar plexus. Watson et al[27] failed in demonstrating an effective advantage of the perineural infusion into the lumbar plexus (VAS score and morphine consumption) after total knee replacement. However, they found a better functional recovery (early mobilization) in those patients receiving an infusion of AL.

We did not find statistically significance between the two groups of patients regarding the VAS score and the tramadol consumption. We just found the necessity of early pharmacological support for those patients receiving single shot anaesthesia. The meaning of this result is not clear. It's reasonable to suppose an important role of the sciatic nerve in postoperative pain[28]: this nerve has been blocked with a single shot anaesthesia in both groups. Because of that, the onset of the postoperative pain couldn't be completely

avoided by use of the perineural catheter in the B group which, in fact, recurred to tramadol. This hypothesis, however, doesn't provide a clear explanation of the delayed onset of the pain in the group B.

Unlike the femoral nerve block, which involves very few risks, side effects related to psoas compartment block are quite severe[29]. Epidural diffusion is the most frequent problem. The reported incidence of epidural diffusion varies greatly in the literature from less than 1% to 16%[20,24]. Epidural catheter localization is also possible[30]. Spinal anesthesia is a feared complication of posterior lumbar plexus block[31]. Two case reports of total spinal anesthesia are available in the literature[32,33]. A case of subarachnoid placement of a catheter, without initial CSF aspiration, was also described[34] Intravascular injection can rapidly lead to seizure, cardiac arrest, and, eventually, death[31,33,35,36].

The best way to prevent toxicity is still a negative test dose and slow fractionated injection. The persistence of a myotonic response with neurostimulation after the injection of 1 mL of normal saline or local anaesthetic should alert the anaesthesiologist to a possible intravascular injection. Deep sedation can mask initial symptoms of systemic local anaesthetics absorption[36]. Delayed reactions can also happen. They are mainly associated with absorption of large local anaesthetic doses. Continuous infusion may also be involved. It highlights the importance of patient surveillance after block performance and during catheter maintenance[31].

Posterior lumbar plexus blocks are best avoided in anticoagulated patients. Renal subcapsular hematomas have been described after the performance of lumbar paravertebral blocks at the L3 level[37]. Two major blood losses associated with psoas hematomas have been reported[38]. Neurologic damage is a major concern during and after lumbar plexus blocks. The frequency of peripheral nerve neurologic complications reported after single-shot peripheral nerve block is not well established (0.02-0.4%)[39,40]. Continuous perineural catheter infection is an issue that has received little attention to date. A strict aseptic technique should be performed to decrease infection risks[40]. Many incorrect localizations have been described: abdominal cavity, the retroperitoneal cavity, the subarachnoid space, the L4-L5 intervertebral disk and the paravertebral space[20,31,33,34].

Posterior lumbar plexus block results in unilateral sympathectomy. Fragile patients may develop hemodynamic instability. Furthermore, a bilateral sympathectomy is possible in the case of an epidural diffusion. Every patient should be monitored during and after the performance of a posterior lumbar plexus block in the same manner as those who receive an epidural block[41]. Nevertheless, it may be suitable a partial sympathectomy, potentially avertable with a correct fluid loading, easily manageable than some adverse hemodynamic effects related to general anesthesia in this kind of patients.

Although our study has shown decreased tramadol consumption, it has not shown any statistically significant improvement in pain scores. The reason is probably in part the study design, with readily available rescue analgesia on- demand. On the other hand, the results suggest that, although there are underlying analgesic benefits of the infusion, these can be replaced by a systemic analgesia. Indeed, looked at from this perspective, it may appear that a reduction in tramadol consumption is of little consequence in itself. The use of Paracetamol is recommended, in combination or not with other analgesics (NSAIDs and opioids), for its sparing-effect on supplemental analgesic use after orthopaedic procedures[21,42,43].

The importance of regional anaesthesia in improving functional recovery is well known[1,2]. Indeed the analgesic action of systemic analgesic drugs is primarily at a supraspinous level; nerve blocks act earlier in the pain pathway, presumably reducing activation of the pain pathways at a spinal level[44]. There is some evidence with other regional techniques that there are benefits of regional blocks not directly related to pain relief (such as reduction in the stress response), and probably the earlier mobilization seen in several study may have been achieved primarily by breaking the cycle of reflex muscle spasm (originating at a spinal level) seen postoperatively[45]. Thus, muscle spasm may not be directly related to pain as perceived at a cerebral level but rather to "wind-up" at the spinal level.

However, continuous perineural infusion is a reason of concern. A recent metanalysis of published studies about postoperative pain after TKA recommended femoral nerve block, based on evidence for a reduction in pain scores and supplemental analgesia (procedure-specific evidence, Level of evidence 1); no recommendation could be made concerning continuous femoral infusion

techniques versus a single bolus because of heterogeneity in study design and inconsistency of procedure-specific data (Level of evidence 4)[21].

Further studies are necessary to point out the absolute advantage of a continuous lumbar plexus infusion instead of a single shot technique, mainly considering the incidence of side effect and higher costs of perineural catheters. We agree with Watson et al[27], in suggesting that the choice of analgesic technique should be grounded in a careful risk/benefit analysis, and if a lumbar plexus block is being performed for analgesia after TKA, then serious consideration should be given to the institution of an infusion.

In conclusion, this study confirms that the combination of lumbar plexus with sciatic nerve blocks is safe and effective for TKA. Either single injection or continuous infusion of Ropivacaine in lumbar plexus provides reliable and long-acting anaesthesia and analgesia, and allows for increased patient comfort during the early postoperative period, and as such, it should allow for earlier and more comfortable mobilization. The addition of the infusion to the single injection blocks easy to perform and adds little time to the technique. We identified no adverse effects in the patients enrolled. Regional anaesthesia is preferable in patients with elevated American Society of Anaesthesiologists scores. Association of regional anaesthesia with acetaminophen and tramadol is advisable to ensure better control of postoperative pain.

Further studies will establish the advantage of continuous lumbar infusion of local anaesthetics in order to increase the duration of the analgesic properties of these peripheral blocks with lower risk profile. These technique raise the possibility of early pain-free physical therapy for several days that may lead to reduced hospital stays, increased patient satisfaction, and significant cost reduction in TKA.

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