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Original Article

Comparison of Local Infiltration Analgesia With Femoral Nerve Block for Pain Treatment Outcome of Total Knee Arthroplasty

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Objectives: This retrospective study compared local infiltration analgesia (LIA) with femoral nerve block (FNB) after total knee arthroplasty (TKA). The aim of the study was to investigate the effect of LIA and FNB, measuring the primary outcome by fentanyl consumption, the secondary outcome by pain scores, and the tertiary measure by postoperative nausea and vomiting incidences. **Methods:** In this retrospective study, medical history records of 99 TKA patients were reviewed from 2 groups: (1) the LIA group was injected with 180 mg of ropivacaine to the wound and (2) the FNB group was treated with FNB with ropivacaine and morphine. All patients received fentanyl-based patient controlled analgesia (PCA). The observation of outcomes was done during 24 hours. **Results:** No difference was detected between two groups on the first postoperative day, and the bolus fentanyl consumption was significantly higher in the LIA group. All recorded visual analog scale (VAS) scores both at rest and with movement were similar at 1-12 hours, but at 13-24 hours VAS scores at rest were significantly less in the FNB group. Postoperative nausea and vomiting incidences were significantly different between the two groups. **Conclusion:** Single shot LIA with ropivacaine reduces the early pain after unilateral TKA. FNB can provide longer analgesia than LIA.

Keywords: Femoral Nerve, Knee Arthroplasty, Postoperative Pain, Ropivacaine

Introduction

Total knee arthroplasty (TKA) is known as having substantial postoperative pain. Optimal perioperative analgesia will enhance functional recovery, including timely recovery of knee mobility, reduce length of hospital stay and reduce postoperative morbidity [1, 2]. Thus, researchers recurrently study pain treatment of the surgery. Pain treatment options that are employed in the clinical practice where the trial has taken place are systemic opioid or nonopioids, epidural analgesia, and peripheral nerve blocks [2].

Systemic opioid analgesics are the most effective treatment of postoperative pain management, especially for surgeries that cause moderate to severe pain. However, opioids often cause adverse side effects such as nausea, vomiting, urinary retention, itchy skin, respiratory depression, constipation and ileus [3]. The American Society of Anesthesiologists recommends using multimodal analgesia in order to decrease usage of opioid drugs [4]. The multimodal analgesia concept uses several agents, each acting at different sites of the pain pathway [5]. Approximately 80% of patients experienced acute pain after surgery, of these patients 86% had moderate, severe or extreme severe pain. Despite increased focus on pain management programs and development of new standards for pain management, many patients continue to experience intense pain after surgery [6, 7]. There are numerous drug combination routes of administration, and timing for administration that have been tested in different types of surgery.

Epidural analgesia is part of multimodal analgesia and may provide good pain control but is associated with side effects such as systemic toxicity, hypotension, inadequate block, pruritus, urinary retention, and nausea and vomiting [8]. The femoral nerve block (FNB) has been recommended as the technique of choice for postoperative pain management for TKA patients in recent years because FNB provides the most effective and long-lasting analgesia with fewer side effects when compared with epidural analgesia [9]. These above mentioned methods require special equipment and tools and a well-trained physician. But the local infiltration analgesia (LIA), as described by Kerr and Kohan, is a simple, effective and safe postoperative pain relief [10, 11]. A promising modality that might help improve postoperative analgesia is a relatively simple technique in which the surgeon directly injects or places a catheter to infuse local anesthetic into wounds at the end of the procedure.

TKA surgery has been performed for the last seven years at the First Central Hospital in Ulaanbaatar, Mongolia. During the first two to three years, postoperative treatment was performed using morphine and metamizol intravenously at fixed hours as well as rectal suppository diclofenac sodium upon patient request. During this period, patient pain treatment was inadequate and patients experienced moderate to severe pain; consequently, their satisfaction was low. In recent years, the FNB method and patient-controlled analgesia (PCA) pump has been used. However, in Mongolia, the medical supply mechanisms are underdeveloped with an inadequate variety of available medicine and frequent interruption and shortage of supply. Specifically, PCA pumps, ultrasound access, nerve stimulators, and insulated needles for nerve blocks are often not available. Moreover anesthesiologists' practical training in peripheral nerve blockade is often inadequate. Therefore, not every patient can receive these pain treatment methods. So surgeons have started using the LIA method at the end of the surgery.

The purpose of the present study is to retrospectively compare the effectiveness of the LIA method with that of FNB for pain treatment in patients who underwent TKA. The secondary objective was to analyze 24-hour opioid consumption and opioid with bolus dose as well as pain score using the visual analog scale (VAS) both at rest and during active movement. The tertiary outcome measures were postoperative nausea and vomiting incidences. Understanding the outcomes of pain treatment will help to improve postoperative pain management and introduce a multimodal procedure depending on the analgesic approach in hospital care.

Materials and Methods

As an initial step, following the regulations of the Ministry of Health and Sports of Mongolia, the approval from the Ethical Committee of the Mongolian National University of Medical Sciences was obtained (Reference No.: 13-16/2A, 10 May 2013).

The study covers a total of 99 patients aged 18-75 years old who underwent TKA performed by the same surgeon between December 2014 and September 2015. There are two groups who were exposed to different pain treatment approaches. Group 1, or the LIA group, consists of 53 patients who were injected with ropivacaine to the wound and ligaments of the knee and group 2, or the FNB group, consists of 46 patients who were treated with FNB with ropivacaine and morphine.

1. Power estimates for the samples

Because the study is retrospective and employs historical data of the patients, the main statistical analysis was an independent t-test. Power calculations were performed for given sample sizes (53 and 46 respectively), effect sizes, and alpha levels. Group sample sizes of 30 and 30 achieved 90.538% power to reject the null hypothesis of equal means when the population mean difference is $\mu1 - \mu2 = 9.0 - 11.0 = -2.0$ with standard deviations of 1.0 for group 1 and 2.5 for group 2, and with a significance level (alpha) of 0.010.

2. Data source and measures of the pain outcome

The records of the patient history and records of the patient monitoring sheet were examined. The patient monitoring sheet was introduced additionally to record pain experience and treatment. Three measures of outcome were analyzed in the study: (1) fentanyl consumption (µg), (2) VAS score, and (3) frequency of nausea and vomiting during the first 24 postoperative hours.

The VAS score was measured at rest and during movement as 1-3 = little or no pain, 4-6 = average pain, 7-9 = severe pain and 10 = worst pain imaginable. Postoperative nausea and vomiting were measured using the score range of 1-4 (1 = mild, 2 = moderate, 3 = severe, 4 = vomiting). The data were recorded at every hour after surgery for 12 hours, and every 2-3 hours in the subsequent 12 hours.

3. Anesthesia and pain treatment technique

All patients received spinal anesthesia. Intrathecal anesthesia was induced in the sitting position at the L3-L4 or L4-L5 level using a 27-gauge Quincke needle in a paramedian approach with a 12-14 mg dose of isobaric bupivacaine (batch 51238, Neon Lab Limited, Mumbai, India). Depending on the height and age of the patients, 20-25 µg of fentanyl (serial number 320613, Moscow Endocrine Factory, Moscow, Russia) was injected in the subarachnoid space.

Before anesthesia the FNB group was treated with single shot FNB. Following sterile preparation of 7.5% tamedin solution and draping of the groin area on the operative side, the FNB was performed with a 21-22 gauge needle (Stimuplex A, B Braun Melsungen AG, Melsungen, Germany) with nerve stimulator (Stimuplex HNS-12, B Braun Melsungen AG) introduced 1-1.5 cm lateral to the femoral artery. The nerve stimulator was set at 2 Hz and 1 mA. When quadriceps contraction and upward movement of the patella were detected, the current was decreased and needle position optimized for evident contraction at a current output of 0.5 mA. A total of 180 mg ropivacaine (7.5 mg/mL, Fresinius Kabi, Sèvres, France) and 5-7 mg morphine were injected.

LIA group patients were injected with 180 mg of ropivacaine into the wound and ligaments of the knee (posterior part of the capsule, around the medial and lateral collateral ligament, patellar ligament, popliteal tendon, tendon of the rectus femoris muscle, and synovial membrane).

A tourniquet was applied around the thigh before the start of surgery and deflated just before wound closure to all the patients. After surgery, all patients were transferred to the recovery room, fluid was given, and urine output was evaluated and observed for 2-3 hours. Patients were administered antibiotics intravenously one hour prior to the surgery, and also received rehabilitation therapy, thromboembolism complication prevention and nausea treatment. Post-operative pain treatment was continued with a PCA with 2 mL fentanyl per hour, with a dose of 20 µg, a bolus of 5 µg, and a lock-out time of 15 minutes. Fentanyl was administered by intravenous PCA pump. A total of 1000 mg metamizol and 75 mg diclofenac sodium was administered three times a day regularly as part of multimodal analgesia.

4. Data analysis

Data analysis was performed using SPSS 17 (SPSS Inc, Chicago, IL, USA). Descriptive statistics were applied to reveal the characteristics of the two groups vis-a-vis age, sex, body mass index (BMI) and duration of surgery. The difference in pain between the groups measured by the fentanyl consumption and VAS score were analyzed based on descriptive statistics and statistical significance was tested using the independent t-test. Frequencies of postoperative nausea and vomiting were compared using the chi-squared test.

Results

Data from 99 patients were analyzed. In the LIA group, 53 patients were studied and in the FNB group, 46 patients were studied. The age, sex, BMI, and duration of operation for the patients are compared in Table 1. The mean age of the patients is 66.1 years for the LIA group and 65.9 years for the FNB group. The proportion of females is high in both groups. Mean BMI of the LIA group is 30.0 kg/m^2 and 27.9 kg/m^2 for the FNB group. Furthermore, the mean duration of surgery is estimated at 1.5 and 1.2 hours for the LIA and FNB groups, respectively. Overall, the characteristics of the groups do not differ substantially and bias towards particular attribute is not observed. Although, statistical significance is observed between the two groups for BMI, clinically, the difference of 2.1 kg/m^2 is not substantial.

Table 1. Characteristics of TKA patients

Characteristics	LIA group (n = 53) Mean ±SD	FNB group (n = 46) Mean ±SD	p-value
Mean age (years)	66.1 ±8.26	65.9 ±8.3	0.895
Sex (percent female)	88.7[a]	89.1[a]	
BMI (kg/m^2)	30.0 ±3.70	27.9 ±3.4	0.006
Duration of surgery (hours)	1.51 ±0.25	1.2 ±0.5	0.185

[a]Values are a percent

Table 2. Fentanyl consumption in TKA patients (μg)

Fentanyl consumption	LIA group (n = 53) Mean ±SD	FNB group (n = 46) Mean ±SD	p-value
Total	489.2 ±26.4	491.7 ±17.5	0.601
Bolus (part of total)	28.0 ±30.8	14.1 ±17.6	0.008

Table 3. Pain level as measured by VAS score in TKA patients presented as the mean ±SD

Time period	VAS score at rest			VAS score with movement		
	LIA group (n = 53)	FNB group (n = 46)	p-value	LIA group (n = 53)	FNB group (n = 46)	p-value
0-5 hours	0.02 ±0.14	0.02 ±0.09	0.904	0.07 ±0.24	0.02 ±0.09	0.176
6-11 hours	0.42 ±0.55	0.53 ±0.68	0.353	0.69 ±0.80	0.78 ±0.75	0.569
12-23 hours	0.96 ±0.98	0.57 ±0.69	0.026	1.47 ±1.37	1.03 ±1.24	0.103
Overall	0.47 ±0.42	0.37 ±0.39	0.273	0.74 ±0.65	0.61 ±0.58	0.290

Table 4. Number (%) of patients experiencing nausea and vomiting

Time period	Nausea		Vomiting	
	LIA group (n = 53)	FNB group (n = 46)	LIA group (n = 53)	FNB group (n = 46)
0-11 hours	15 (46.9)	77 (59.7)	3 (33.3)	29 (76.3)
12-23 hours	17 (53.1)	52 (40.3)	6 (66.7)	9 (23.7)
Total	32	129	9	38
p-value	0.266		0.037	

The primary purpose of the present study as mentioned above was to determine the demand of opioid consumption. On the first day after operation, the fentanyl consumption in the LIA group was 489.2 ±26.4 μg and in the FNB group was 491.7 ±117.5 μg (p = 0.601). Fentanyl consumption during the active treatment period (0-24 hours) was not statistically different between groups (Table 2). Fentanyl consumption with bolus was 28.0 ±30.8 μg for the LIA group and 14.1 ±17.6 μg for the FNB group (p = 0.008) indicating a statistically significant difference (Figure 1). For the secondary outcome, VAS score at rest was 0.416 ±0.374 for the LIA group and 0.388 ±0.397 for FNB group, while the VAS score at movement was 0.750 ±0.645 for the LIA group and 0.736 ±0.713 for the FNB group. At the first 12 hours after the surgery, VAS score between two groups was not significantly different, however between 13-24 hours there was a statistically significant difference. Between 13-24 hours after the surgery, VAS score at rest was 0.959 ±0.980 for the LIA group and 0.569 ±0.687 for the FNB group (p = 0.026, Table 3). Frequency of nausea and vomiting differed substantially between LIA and FNB groups with the LIA group demonstrating lower frequencies (Figure 2, Table 4), however this result was not statistically significant.

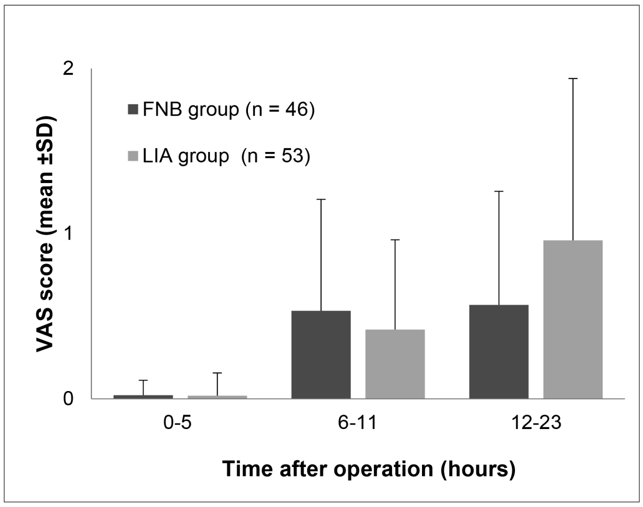

Figure 1. VAS score at rest for TKA patients.

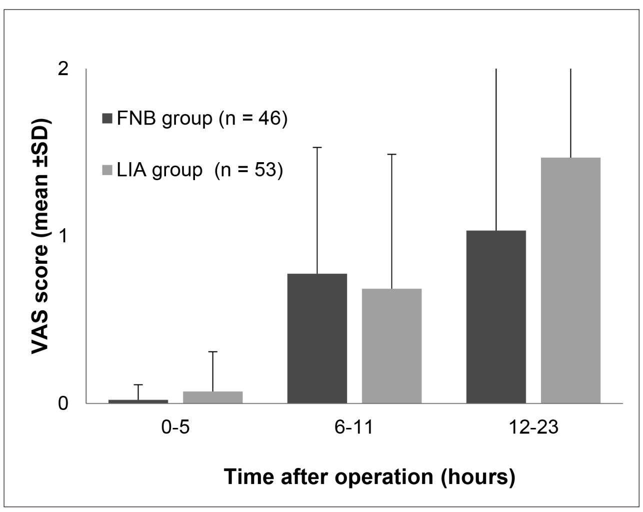

Figure 2. VAS score with movement for TKA patients.

Discussion

The present retrospective study showed that average fentanyl consumption for two groups was similar in the first 24 hours after TKA surgery, but bolus fentanyl consumption for the FNB group was significantly lower than the LIA group (p = 0.008). Although postoperative VAS scores of the two groups were similar for the first 12 hours after the surgery, VAS score at rest was significantly lower (p = 0.019) for the FNB group than the LIA group between 12-23 hours which is similar to the findings of other studies [12, 13].

There were differences in the incidences of postoperative nausea and vomiting. Use of 5-7 mg of morphine with the FNB group could have led to the higher frequency of nausea and vomiting among the FNB group patients compared to the LIA group. In a randomized, double-blind, placebo controlled study, Specht et al. showed that with LIA, there is some evidence of a decrease in postoperative nausea and vomiting [14]. The risk of nausea and vomiting was not assessed and registered in patients' medical history preoperatively in the present study. Therefore, there is a possibility that patients of the FNB group could have been from the group who is more prone to nausea and vomiting.

Non-steroidal anti-inflammatory drugs, opioid by patient controlled pumps, local infiltration, and FNB are options of the multimodal analgesia. LIA and FNB pain management methods are both used in TKA surgeries at the clinic. Multimodal analgesia was used in TKA and is critical for improvement of the rehabilitation and reduction of the hospitalization days [1, 2, 4]. Among these methods, FNB is considered as the gold standard because of its effectiveness [9]. However, additional tools, equipment, ultrasound access, nerve stimulators, insulated needles and bacterial filters are required. It is also accompanied with some complications. The physician performing the nerve block should be well-trained and experienced in order to reduce the risks of neuritis, neuropathy and sudden falling of the patient, which is the most common complication associated with the FNB [15].

Despite this, the FNB is considered as one of the most adequate pain treatment methods for TKA. In recent years, much comparative research has been done concerning LIA which is administered as a single shot or in a continuous manner. In addition, it is also done individually or with analgesic drugs such as ketorolac adrenaline, steroids and antibiotics [10, 11, 16-19]. The advantage of the LIA method is its simplicity and the fact that it can be performed by a surgeon. However, there are some major complications for this method, which are wound infection and local anesthetic toxicity. In the study of Ali et al., continuous LIA appeared to have no significant effect on postoperative pain and a higher rate of wound-healing complications and deep wound infections occurred [20].

According to the study of Affas et al., the LIA method treats pain as effectively as the FNB method at the first 24 hours and LIA is an easier method compared to FNB [21]. Toftdahl et al. compared LIA and FNB in a continuous method [22]. The LIA group had significantly lower pain scores at movement and lower consumption of opioids at the first 24 postoperative hours [22]. YaDeau et al. found that the LIA group used bupivacaine, morphine, methylprednisolone and cefazolin in combination and the FNB group was treated with FNB and the continuous epidural method [23]. The pain treatment results of these two groups were similar, when regional analgesia is not possible to be used. LIA with the combination of drugs is an effective pain treatment method, however VAS score was lower for the FNB+epidural group [23]. The dose of opioid was 228 mg (oral morphine) for the LIA group, and 142 mg for FNB+epidural group [23]. The feature of the study is that the combination of the two pain treatment methods (FNB+epidural) is compared to continuous LIA [23]. In addition, both groups used analgesic drugs such as oxycodone, meloxicam, paracetamol, ketorolac and if necessary hydromorphone pumps [23]. Use of a clonidine patch and controlled release oxycodone in the LIA group could have played a determining role in conclusions on the efficiency of the LIA method [23]. It has to be noted that studies discussed here used higher doses of local anesthetic and it has been combined with other analgesic drugs. Furthermore, the continuous method was widely used for administration of LIA [11, 14, 20, 21]. Ropivacaine is a long-acting local anesthetic and has less cardiac toxicity than bupivacaine, but when using high doses it suppresses the central nervous and cardiovascular system. Therefore, a lower dose was administered to secure patients' safety in the First Central Hospital. Many studies examined ropivacaine levels in blood after LIA and concluded that no toxic concentration of ropivacaine was observed. Also there is a study which showed that it is safe to perform LIA after auto transfusion of patients undergoing lower limb arthroplasty [24].

According to a meta-analysis by Mei et al., both LIA and FNB analgesic regimes for TKA are effective in reducing the pain and use of opioids [12]. Carli et al. observed that the continuous FNB method reduced opioid consumption and improved recovery at 6 weeks more than periarticular infiltration analgesia [25]. Krenzel et al. used low doses of ropivacaine in the posterior capsule of the knee, however, it did not affect positively the pain result [26]. Rosen et al. compared the groups treated with single shot ropivacaine in the knee capsule with the placebo group [27]. In the first 24 hours, although the LIA group demonstrated lower levels of pain, it was not statistically significant. No substantive differences were observed in fentanyl consumption [27].

Moghtadaei et al. reported that the LIA treatment group that used ropivacaine, adrenaline, and ketorolac as part of the analgesia had low VAS score and lower consumption of opioid than the FNB group [13]. However, between 6 hours and 24 hours, the VAS score and consumption of opioid was the same as the FNB group and between 24-48 hours, the VAS score and opioid consumption was lowered for the FNB group [13].

The limitation of the present study is its retrospective nature and data on postoperative rehabilitation was not available. To confirm the findings, prospective investigations are needed. Secondly, ropivacaine was used exclusively whereas in other studies this has been used only in combination with other drugs. Provided the risks of contamination associated with continuous and combined methods in the context of Mongolia, only sterile ropivacaine was used. There are no facilities to perform sterile combination of different drugs in Mongolia. Thus, the efforts should be made to explore more effective ways of multimodal analgesia including continuous FNB and continuous cocktail LIA. Thirdly, the side effects of nausea and vomiting were measured in frequencies rather than levels of severity. As mentioned above the incidence of nausea and vomiting among the FNB group could have been due to the injection of the combination of the ropivacaine with morphine.

Future research could improve upon these limitations. Additional areas of research could be pain management in Mongolia since there is a lack of studies examining the pain tolerance. There are no guidelines on the management of the postoperative pain treatment in the hospitals of Mongolia, which drives the need for further research in this area. Further, studies examining the effect of anesthesia types as well as the duration of operation and anesthesia on postoperative pain are needed.

In conclusion, LIA to the wound and ligaments of the knee was beneficial for reducing near-early postoperative pain. However, FNB proved to be relatively long lasting and more effective for reducing the consumption of opioids. Thus, the LIA method is regarded as a simple method that can be used when the FNB method cannot be used.

Conflict of Interest

The authors state no conflict of interest.

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