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ORIGINAL STUDY

Comparison of local infiltration analgesia with single injection femoral nerve block in total knee arthroplasty

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The purpose of this study was to compare the analgesic and hemostatic effects of Local Infiltration Analgesia (LIA) with single injection femoral nerve block (SFNB). A database of patients undergoing knee arthroplasty between 2008 and 2013 was analyzed. A group of patients who underwent minimally invasive TKA either with SFNB (n = 112) or with LIA (n = 112) were matched.

In the early postoperative period, the LIA group had a significantly lower VAS score, a lower drop in Hb and a lower length of hospital stay.

Both the SFNB and LIA techniques provide excellent pain relief following TKA. Nevertheless, LIA reduces pain better in the very early postoperative period by a more complete nerve blockade allowing immediate postoperative mobilization and ambulation leading to a shorter hospital stay. Furthermore, LIA decreases perioperative blood loss by its local hemostatic effect.

Keywords : Knee arthroplasty ; blood loss ; local infiltration analgesia ; single injection femoral nerve block.

INTRODUCTION

As with many other surgical procedures, pain and risk of bleeding are two major concerns with total knee arthroplasty (TKA). Literature has shown that knee arthroplasty causes moderate to severe postoperative pain, which can limit recovery, leading to reduced mobility and prolonged hospitalization *(3)*. TKA can also result in substantial postoperative blood loss, with most reports estimating volumes ranging from 300 to 1000 mL *(23)*. According to a recent report, transfusion rates after TKA can still be as high as 63% to 94% *(18)*.

Oral NSAIDs, patient-controlled analgesia (PCA) and epidural analgesia (EA) are often used as analgesic options for TKA, but they do have some limitations. High quantities of NSAIDs increase the risk of gastro-intestinal complications. PCA is

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linked with morphine-related side effects, such as nausea, vomiting, pruritus and sedation. Epidural Anesthesia (EA) is associated with complications such as motor block, delay in physiotherapy, involvement of both knees, hypotension, urinary retention, pruritus and the postponement of anticoagulant administration due to the risk of epidural hematoma *(12,21)*.

The knee joint is innervated anteriorly primarily by the femoral nerve. One of the most frequently used analgesic modalities in TKA is the single injection femoral nerve block (SFNB), a peripheral neural blockade technique. Its many advantages include a reduction in opioids after TKA. However, recent reports show that SFNB has a better side effect profile than EA but can lead to femoral neuropathy, neuritis and postoperative falling *(24)*. Vascular puncture and nerve damage have also been reported after SFNB *(21)*. In addition, the sciatic nerve innervates the posterior part of the knee, which is not anesthetized by femoral nerve block, leading to residual posterior pain *(20)*.

Kerr and Kohan were mainly the first proponents developing the Local Infiltration Analgesia (LIA) technique *(17)*. LIA consisted originally of an injection of a mixture of local anesthetics, NSAIDs and adrenaline intraarticulary or periarticulary into the knee joint during the operation. It is easy to perform and less expensive than SFNB, making it an attractive alternative to SFNB *(1)*. Other authors have constituted different cocktails *(22)* and other groups reduced the infiltration substance to the local anesthetic *(7)* with or without adrenaline. Recently, Bhutta et al reported that the LIA technique also reduces blood loss and the risk of blood transfusion *(6)*.

There is still disagreement whether LIA or SFNB leads to better outcomes and only a few investigators have compared the two techniques as a single part of perioperative pain release. Chan et al concluded that there was insufficient evidence to definitively compare femoral nerve block and local infiltration analgesia *(10)*. Other studies have found that the femoral nerve block is more efficient for range of motion (ROM) and pain control postoperatively *(8)*. Yun et al recently concluded that LIA is superior to FNB for patients with TKA *(28)*. This retrospective study aims to share our long-term center experience with the use of single injection femoral nerve block and with local infiltration analgesia in order to compare the advantages of the two techniques for TKA. The clinical advantage of LIA being obvious if it is able to relieve pain as efficiently or better than SFNB without the required resources and potential complications but furthermore reducing blood loss after TKA. Our hypothesis was that LIA could achieve as good or better immediate pain relief and less blood loss than SFNB after TKA.

MATERIAL AND METHODS

A retrospective comparison study was performed on patients with a diagnosis of primary knee osteoarthritis undergoing minimally invasive TKA either with SFNB or with LIA in a university hospital. Within a group of consecutive patients undergoing primary knee arthroplasty from 2008 to 2013, 193 TKA with SFNB and 469 TKA with LIA were performed under general anesthesia. All knee arthroplasties performed at our institution are in a prospective database with blood tests performed preoperatively, day 2, day 4, day 21 and day 42. The data were retrieved from the operating software for patients' medical records of our institution (Medical Explorer). Inclusion criteria were tricompartmental osteoarthritis without prior open surgery except meniscectomy, which were treated with the implantation of a cemented Vanguard PS (Zimmer Biomet Inc, Warsaw, IN) total knee with resurfacing of the patella. Exclusion criteria were previous high tibial osteotomy, extra-articular deformities, presence of metallic hardware, an American Association of Anaesthetists (ASA) score > 3, use of preoperative anti-coagulation therapy allowing peri-operative aspirin use however. Inflammatory joint disease was also excluded because of potentially higher bleeding risks in case of synovectomy.

One hundred and twelve TKAs treated with SFNB were selected because of the presence of all data on file. The study group (n = 112) that comprised patients treated with LIA were randomly selected and frequency-matched according to gender, age, and BMI. The study population of TKA patients treated with SFNB was then compared to the LIA group to verify whether appropriate matching had taken place. The local ethics committee approved this retrospective study.

Baseline data was collected for each TKA patient: age, sex, BMI, type of anesthesia, ASA score (comorbidity score), Kalkman score (risk of pain after surgery score) *(15)* and preoperative hemoglobin. The characteristics of the study group are presented in Table I.

Table I. – Baseline characteristics

	SFNB (n = 112)	LIA (n = 112)	p-value
Age (Years)[a]	71 (9)	71 (9)	0.751
BMI (kg/m²)[a]	30 (5)	30 (5)	0.858
Females (%)	85 (75.9)	85 (75.9)	1.00
ASA score			
1	1 (1)	3 (3)	0.003
2	84 (75)	100 (89)	
3	27 (24)	9 (8)	
Kalkmann Score	26 (23)	25 (22)	0.873
≤44	86 (77)	87 (78)	

Values are n (percentage) unless stated otherwise. [a] Mean (standard deviation). Abbreviations: ASA: American society of anesthesiologist; BMI: body mass index; SFNB: single injection femoral nerve block; LIA: local infiltration analgesia; N: number.

Surgical and tourniquet time was retrieved from the anesthetist database. Hospital stay was registered to differentiate the impact of pain and transfusion on LOS, if it occurred.

All patients underwent primary knee arthroplasty using general anesthesia with intensive per-operative temperature monitoring and prevention of hypothermia. At induction, 1 g of tranexamic acid was administered to all patients. Prior to incision, the tourniquet was inflated to 280 mmHg and released after implantation of all components, including the definitive liner. An identical minimally invasive medial approach was performed in both groups. An intramedullary femoral guide and an extramedullary tibial guide were used. The femoral hole was plugged in every TKA. Bone cuts and soft tissue balancing appropriate for valgus or varus knees was performed in the same sequence for each procedure. Bovie coagulation was used on the soft tissue areas and nothing was used on the bony surfaces. The joint capsule and wound were closed in layers without the use of drains.

Anesthesia and Analgesia Procedures

Patients in the SFNB groups received the femoral blcok before general anesthesia. The femoral artery was located below the inguinal ligament and the femoral nerve was located laterally to the artery with the use of a peripheral nerve stimulator (Anaestim MK III, Meda, Belgium) until 2010 and after that period with ultrasound. After negative testing for aspiration of blood, 25 mL ropivacaïne 0.5% (Naropin, AstraZeneca, Belgium) with epinephrine 1:200 000 was injected. The cutaneous sensibility in the area of the femoral nerve was assessed by using a cold test (ether).

Patients in the LIA group received a 200 mL injection of 0.2% ropivacaïne (Naropin, AstraZeneca, Belgium) with epinephrine 1:200 000 according to a standardized technique. After the medial arthrotomy the soft tissues surrounding the femur are injected progressively. Usually the injections are done on the medial periost of the femur, the anterior soft tissues of the femur and the lateral periost to finish with a para-femoral injection on both sides. Then the femoral cuts can be performed. The next stage of infiltrations comes before cutting the tibia. The periost and soft tissues are injected and then the tibial cut is made. After cleaning out the posterior tissues and osteophytes the posterior bone is injected while staying close to the bone, as well as the meniscal remnants, posterior capsule and tibial posterior capsule. After implantation of the components the third phase of injections gives infiltrations of the Hoffa fat pad, suprapatellar poach and around the tibial insertion of the medial collateral ligament. Especially when adrenaline is used caution is necessary for subcutaneous injections of the skin.

The rehabilitation program was identical for both groups, consisting of full weight bearing without aid and active range of motion exercises from day 1. Thrombosis prevention was done with low molecular weight heparin (LMWH) for 21 days after surgery; dosage was adapted according to the weight of the patient. Criteria for discharge were a dry wound, oral pain medication, no need for blood transfusion, ambulation without aid and minimal 90° of active flexion.

The postoperative visual analogic scale (VAS) was collected for both groups in the recovery room on the day of surgery, on days 1, 2, and 3 after surgery and on the last day of the hospital stay. VAS scores at recovery room entry and exit (respectively, "VAS in" and "VAS out"), as well as individual maximum VAS score ("VAS max"), were collected.

Hb levels were determined for each patient before and after surgery and on postoperative days 2 and 4 via blood tests for both groups. In addition, Hb was measured 3 and 6 weeks postoperatively. Drops in Hb levels were calculated by subtracting each postoperative Hb value from the preoperative value. Transfusions, if any, and number of units transfused, were noted in the prospective database.

The American Association of Blood Banks clinical practice guideline on transfusion recommends the use of restrictive protocols in which transfusion is considered only in patients whose hemoglobin level is ≤ 8 g/dL *(9)*. The guideline also recommends the use of clinical symptoms as well as the hemoglobin level in determining when to use transfusion. We strictly applied these criteria and the decision to transfuse was made by our internist (JCY).

Statistical Analysis

Categorical variables are presented as frequencies and percentages. Continuous data are presented as mean and standard deviation. The Fisher exact test for categorical variables was used to perform univariate analysis. An independent statistician used Stata/SE 12 (StataCorp, College Station, TX, USA) to analyze all outcome variables.

Treatment comparisons for continuous outcome were based on linear mixed models *(27)*. Linear mixed models are extensions of the commonly used linear regression models. In linear regression models, independence of all observations is assumed, whereas linear mixed models take into account correlations between successive measurements of the same patient. These models are, therefore, suitable for the analysis of longitudinal data, as they show the development of outcomes over time. We analyzed VAS pain and drop in Hb level. Models were fitted containing the main effects treatment group, time, and their interaction (group–time interaction). Separate intercepts and time terms were estimated for each group. Random effects were included for each group and the time term. Linear contrasts of fitted model estimates were constructed, and Wald tests were used to calculate statistical significance of the group-time interaction and the significance of differences in outcome for each time point. Two-tailed tests were used throughout. Two-sided p-values < 0.05 were considered to be significant.

RESULTS

LOS was longer for TKA with SFNB than for TKA with LIA (5 (SD, 1.4) days and 4 (SD, 0.9) days respectively, p < 0.001). The results for VAS in the recovery room are as follows. On admittance to the recovery room, pain was higher for TKA with SFNB (mean, 3.2, 95% CI, 2.8 – 3.6) than for TKA with LIA (mean, 2.3 (95% CI, 1.9 – 2.7)) (p = 0.001). Mean VAS at dismissal of recovery room were 3.1 (95% CI, 2.7 – 3.4) and 1.0 (95% CI, 0.6 – 1.3) for SFNB and LIA, respectively (p < 0.001) (Figure 1). The drop in pain during recovery room stay was more pronounced for the LIA group (p < 0.001). Maximum pain on the VAS during stay in the recovery room were 4.8 (95% CI, 4.3 – 5.3) for SFNB and 3.3 (95% CI, 2.8 – 3.8) (p < 0.001) for LIA, respectively.

Table II. — Mean pain on the Visual Analogue Scale

	SFNB (n = 112)	LIA (n = 112)	p-value
Preoperative	3.9 (3.6 – 4.2)	3.6 (3.3 – 3.9)	0.191
Day 1	4.7 (4.4 – 5.1)	4.2 (3.9 – 4.5)	0.025
Day 2	4.0 (3.7 – 4.3)	3.7 (3.4 – 4.0)	0.219
Day 3	3.5 (3.1 – 3.8)	3.4 (3.1 – 3.7)	0.766
Day 4	3.1 (2.8 – 3.5)	2.9 (2.6 – 3.2)	0.372

All values are mean (95% confidence interval). Abbreviations: SFNB: single injection femoral nerve block; LIA: local infiltration analgesia; n: number

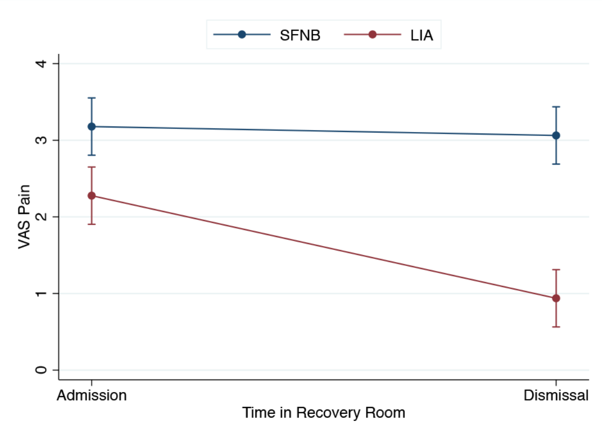

Fig. 1. — Graph showing mean pain on the Visual Analogue Scale. Vertical bars indicate 95% confidence interval

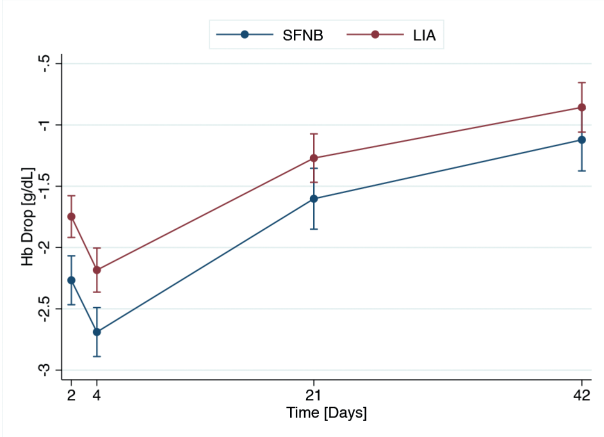

Fig. 2. — Graph showing mean change in Hb. Vertical bars indicate 95% confidence interval

The results for VAS during hospital stay (after recovery room) are presented in Table II. On the first postoperative day, pain was lower for TKA with LIA (p = 0.025). However, there were no significant differences between the groups that held consistently over time, and postoperative VAS showed similar patterns for the two groups (overall trajectory p-value = 0.690).

No transfusions were registered for either group. The mean drop in Hb level was significantly higher for the SNFB group at all postoperative time points, and the differences between the groups held consistently over time (p = 0.286). The development of the mean Hb levels over time for both groups is presented in Table III and in Figure 2.

DISCUSSION

To the best of our knowledge, there has not been a large amount research into the merits of single injection femoral nerve block versus local infiltration analgesia for postoperative pain relief and, especially for the reduction of TKA bleeding. The purpose of this retrospective study, therefore, was to gain a greater understanding into the advantages and disadvantages of these two anesthetic techniques by reviewing our database of patients.

Table III. — Mean hemoglobine drop

	SFNB (n = 112)	LIA (n = 112)	p-value
Day 2	-2.3 (-2.5 – -2.1)	-1.7 (-1.9 – -1.6)	< 0.001
Day 4	-2.7 (-2.9 – -2.5)	-2.2 (-2.4 – -2.0)	< 0.001
Day 21	-1.6 (-1.9 – -1.4)	-1.3 (-1.5 – -1.1)	0.041
Day 42	-1.1 (-1.4 – -0.9)	-0.9 (-1.1 – -0.7)	0.109

All values are mean (95% confidence interval). Abbreviations: SFNB: single injection femoral nerve block; LIA: local infiltration analgesia; n: number

The most significant finding of our study was that local infiltration analgesia provides more immediate postoperative pain relief than a single injection femoral nerve block. VAS scores recorded in the recovery room were lower for the LIA group than for the SFNB group. On the the first postoperative day, pain was lower for the LIA group. This may, however, be attributable to baseline differences in pain levels. For the rest of the hospital stay we found no differences in terms of pain. There are two possible explanations for the early differences in pain in the recovery room. Firstly, neuroanatomic studies have shown that the knee joint is innervated by three principal nerves: the femoral nerve, the sciatic nerve and the obturator nerve *(16)*. When we performed a femoral nerve block, only the anterior part of the knee was anesthetized. The other parts of the knee, specifically the posterior capsule, are innervated by the sciatic nerve. In LIA protocols the anesthetic product is disposed in the anterior part to anesthetize the femoral fibers but also in the posterior capsule to anesthetize the sciatic fibers and often infiltration posterior to the capsule is performed blocking the nerves directly. It is possible that SFNB patients experience more pain than LIA patients in the recovery room due to the fact that sciatic fibers were not anesthetized.

The analgesic product we used for both SFNB and LIA groups in this study was ropivacaine, a long-acting amide local anesthetic agent. Ropivacaine causes reversible inhibition of sodium ion influx, increases action potential threshold, which serves to block generation and conduction impulse in nerve fibers *(13)*. Some studies using ropivacaine showed that intraoperative LIA was apparently effective for the 6 - 12h after surgery *(2)*. The peak effectiveness of ropivacaine in the early hours after injection may explain why there was no difference between the two groups in terms of pain during the rest of hospital stay.

Several studies have shown similar results to our own regarding timing of pain relief. Ashraf et al showed in their study that LIA had significantly lower pain scores than SFNB four hours post-operatively (2.1 (SD 2.6) vs 6.8 (SD 3.2), $p < 0.01$) (5). Toftdhal et al reported lower pain in the LIA group on the first postoperative day *(26)*. Chaumeron et al demonstrated pain at rest was lower in the LIA group during the first eight postoperative hours *(11)*. However, Affas et al performed a randomized study, and concluded that LIA and SFNB gave similar quality of pain relief during the first 24 hours, with neither of the two analgesic regimens demonstrating a clear superiority *(1)*.

Another important finding in our research was that LIA had less blood loss than SFNB during TKA. Blood loss can be "visible" and estimated during the surgical procedure by observing the aspirated amount of blood, by weighing used sponges or by observing the amount of blood in the postoperative drain. Blood loss can also be "hidden" and occur after surgery (or after the removal of drains); it can either infiltrate into the soft tissues or remain in the joint space as a haematoma. Intra-operative and postoperative blood loss are known complications of TKA. Bone and soft-tissue bleeding following TKA can be a major cause of morbidity leading to hypovolemia, transfusion, pain, cardiac co-morbidity, slower rehabilitation due to hematoma formation, stiffness, wound breakdown and increased risk of infection *(18).*

Local infiltration analgesia contains epinephrine which has strong alpha-adrenergic effects resulting in local vasoconstriction and increased vascular permeability in and around the knee during surgery. In our study, the hemoglobin drop between the preoperative day and day 2 was lower in the LIA group than it was inthe SFNB group. However, there were no differences between the two groups in terms of hidden blood loss (hemoglobin drop between day 2 and day 4 postoperatively). LIA containing epinephrine, therefore, appears to help decrease blood loss only perioperatively.

Our results on blood loss under local infiltration are consistent with previous findings. Lombardi et al showed that soft tissue and intra-articular injection of bupivacaine, epinephrine, and morphine decreased blood loss and bleeding indices during the immediate postoperative period *(19)*. Later, Anderson et al performed direct measurement of drain output, and found a statistically significant decrease in blood loss in their LIA group *(4)*. Recently, Bhutta et al studied the use of LIA and a second intra-articular bolus of the same LIA solution in perioperative blood loss and postoperative transfusion rates *(6)*. They found that this method was effective in reducing perioperative blood loss by 1g/dl and transfusion rates by 82%. Spangehl et al found a periarticular injection with ropivacaine, epinephrine, ketorolac, and morphine equally effective as a combined femoral and sciatic block *(25)*. Hinerajos et al found that the addition of LIA to peripheral nerve blocks after TKA surgery only provides minimal benefit for pain relief *(14)*. However, they also assessed whether LIA has an incremental benefit to femoral and sciatic NB, and their findings do not contradict ours.

Our study also found no difference in tourniquet time suggesting there is no or no significant time loss by the LIA procedure. This finding also confirms the surgical procedure was comparable over time with the use of the same implant. Only the total surgical time was reduced over time with an adaptation of the closure technique. This change is not relevant to the parameters studied here.If the SFNB group is performed in the same room as the surgery (in the absence of a pre-narcosis room) the impact on time management might be important. The execution of a femoral nerve block asks for resources and time. This starts with disinfecting the femoral area, finding the nerve with the ultrasonic guidance technique or electrostimulation, and then performing the femoral blockade. These steps accounted for about 13 minutes time difference between the two groups. If that extra 13 minutes is multiplied by the five operations per day then medical costs are significantly impacted.

In this study, a shorter length of hospital stay in the LIA group was observed that can be explained by the decreased immediate postoperative pain which allowed for early rehabilitation, starting on the same day of surgery. Patient were also capable of early full weight-bearing, allowing them to be autonomous earlier in the absence of muscle weakness.

This retrospective review is limited by its design. We did not have at our disposal other outcomes which may have been interesting to explore, such as morphine consumption during hospital stay. Additionally, we could not compare certain outcomes because of the difference of measure within both study groups. For example, range of motion was randomly recorded in the two groups as active or passive or through the values obtained with a Continuous Passive Motion device earlier on. Nevertheless, the strength of this study lies in the fact that all conditions were comparable allowing us to retrospectively study matched groups according to analgesic approaches.

In conclusion, our study showed three advantages of LIA compared to SFNB: it decreases immediate postoperative pain needing less morphine and therefore interesting in a day-care arthroplasty setting and it reduces perioperative blood loss and length of stay without increasing the surgical time. By extension, LIA allows early rehabilitation, decreases transfusion-related complications and reduces medical costs.

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