The Effects of Single Shot versus Continuous Femoral Nerve Block on Postoperative Pain and Rehabilitation Following Total Knee Arthroplasty

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ABSTRACT

Peripheral nerve blocks are useful for postoperative pain control and are without side effects typically observed in intravenous opiate-based patient controlled analgesia (PCA). In this retrospective study, we analyzed patients who utilized either PCA with single shot femoral nerve block (SFNB) or continuous femoral nerve block (CFNB) following TKA, and the impact of the choice of postoperative analgesia choice on postoperative rehabilitation and recovery. Also included were those who had peripheral nerve blocks administered for the surgical procedure. Using data from 54 patients (25 SFNB & 29 CFNB), we studied VAS pain scores, time to ambulation, knee range of motion at discharge, hospital length of stay (LOS) and complications. Pain scores at rest and during mobilisation were significantly lower amongst patients who received CFNB compared to SFNB. The CFNB group also achieved independent ambulation more rapidly. In conclusion, CFNB provided efficacious postoperative pain control with enhanced rehabilitative recovery in patients undergoing TKA as compared with SFNB/PCA patients.

Key Words:
Knee Arthroplasty, Nerve Block, Post-operative Pain, Analgesia, Total Knee Rehabilitation

INTRODUCTION

TKA is one of the most commonly performed elective orthopaedic procedures. According to the National Hospital Discharge Survey in the USA, 381,000 primary knee replacements were performed in the year 2002 alone. The total number of knee replacement surgeries more than doubled over the 1990s, with an average increase of 1730 primary operations and 266 revision operations a year [1,2]. Locally, 1517 primary total knee arthroplasties were performed from December 2005 to November 2006, according to data from the Ministry of Health, Singapore [3].

Patients typically experience severe and sustained postoperative pain following total knee arthroplasty (TKA)[4,5]. Optimal postoperative pain control is a critical determinant of successful passive and active range of knee motion following TKA. Early knee mobilisation following surgery has been associated with decreased risk of deep vein thrombosis and good long-term functional outcomes [6,7]. Conventional postoperative pain relief is provided by either intravenous patient-controlled analgesia (PCA) or epidural analgesia. Opioids and opiate derivatives are the predominant agents of choice in PCA. Opioids, however, do not consistently provide adequate pain relief and often are associated with the following side effects: sedation, constipation, nausea or vomiting, pruritis and urinary retention [8]. Epidural analgesia has been reported to cause side effects such as headaches, spinal haematomas, hypotension, motor blockade, syncope or even meningitis [9].

Recently, peripheral nerve blocks have been reported to deliver optimal postoperative pain control and have been increasingly used for patients undergoing orthopaedic procedures [10,11]. Several studies report that peripheral nerve block provides a quality of analgesia and surgical outcomes comparable to PCA or epidural analgesia without the associated side-effects [11,12]. There are two main types of peripheral nerve block techniques that are utilized for postoperative analgesia for TKA patients: single-shot injection vs. continuous infusion technique.

Single-shot femoral nerve blockade (SFNB) has been proven to improve postoperative analgesia and reduce hospital length of stay [10,13,14]. The immediate benefits of SFNB may be extended over a longer postoperative period by placement of a femoral nerve catheter in-situ thereby enabling continuous infusion of analgesia. Such continuous femoral nerve block (CFNB) provides protracted site-specific regional analgesia beyond the first 24hrs postoperatively. Continuous femoral nerve blocks (CFNB) thus provide superior analgesia as compared to PCA and recovery of physical function and hospital length of stay (LOS) is comparable [10,12,15].

Peripheral nerve blockade for limb surgery, as augmentation to spinal anaesthesia or for postoperative pain control, has being increasingly utilized in the authors' institution over the last two years (Fig.1). However, the introduction of analgesia at the site of the femoral nerve can be associated with

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muscular weakness thus limiting quadriceps strength. The use of infusion catheters would consequently be expected to prolong the period of weakness and thus increase the rehabilitation period when compared to single shot femoral nerve blocks. This phenomenon was noted in some TKA patients who had peripheral nerve blocks for the surgical procedure.

The purpose of this study was to compare the effects on postoperative pain and rehabilitation (range of motion, hospital LOS) in relation to the type of peripheral nerve block (SFNB vs CFNB) that was administered as augmentation to spinal anaesthesia, for patients undergoing total knee arthroplasty.

MATERIALS AND METHODS

A retrospective study was conducted on 374 patients undergoing total knee arthroplasty at the authors' institution over a 12 month period. Primary total knee arthroplasty and the use of peripheral nerve blocks were the inclusion criteria for this study. Of the 374 TKAs performed, 58 surgeries in 56 patients utilized a peripheral nerve block for postoperative pain control.

Patients were reviewed preoperatively by the senior anaesthetist and were administered either SFNB or CFNB based on their typical clinical practices of the physicians on these cases. SFNB was administered in the induction room with the aid of nerve stimulators for femoral nerve localization. CFNB was administered similarly, except that an infusion catheter is left in-situ in the vicinity of the femoral nerve. Ultrasound guidance was used as needed in obese patients to verify femoral nerve anatomy. Following the peripheral nerve block, spinal anaesthesia is administered. A fixed combination of lignocaine and bupivacaine was used for the peripheral nerve block for the benefit of both long acting and short acting properties of the combination medication.

Senior orthopaedic surgeons performed all surgeries. Patients received perioperative intravenous antibiotics and all patients underwent a medial parapatellar arthrotomy. All patients received posterior cruciate substituting implants and underwent patella resurfacing. All prostheses were implanted using hand-mixed cementing techniques and all had one or two drains placed into the wound. None received administered intra-articular analgesia or corticosteroid injections. All patients wore compression stockings postoperatively for deep vein thrombosis (DVT) prophylaxis and subcutaneous low-molecular-weight heparin (LMWH) was used postoperatively for prophylaxis as well.

All patients were placed on a standard total knee clinical pathway program that is used in the authors' institution. Postoperative analgesia was supplemented in the SFNB group using intravenous PCA, which was set to deliver 1mg boluses of morphine with a 5-minute lockout period. In the CFNB patients, analgesia requirements were titrated accordingly and administered via the infusion catheter. In both groups of patients, oral analgesia was given for break-through pain (termed "oral rescue analgesia"). Physiotherapists used a rehabilitation protocol driven towards early range of motion exercises, reviewed all patients, and started ambulatory therapy from the first postoperative day (POD). All patients received knee range of motion using the continuous passive range of motion (CPM) machine. The standard rehabilitation schedule is as follows: 1st POD: CPM and standing exercises; 2nd POD: Ambulation with walking frame; 3rd POD: Ambulation with Quad-stick; 4th POD: Obstacle clearance (i.e. clearance of small steps and curbs); 5th POD: Staircase climbing

Pain scores were charted using the visual analogue scale (VAS) with a range from 1 to 10 (Fig 2). The senior nursing staff and the physiotherapist documented both pain at rest and at mobilisation. The anaesthesia pain service team regularly reviewed the analgesia requirements of both patient groups. Side effects such as excess sedation, lignocaine toxicity, nausea, vomiting, pruritis, respiratory depression and urinary retention were also recorded.

Patients were discharged home or to a rehabilitation centre. Discharge criteria indicated in the clinical pathway requires the patients to have no medical complications and have demonstrated satisfactory ability to sit, stand and ambulate on level ground as well as negotiate stairs. Many patients in our local setting reside in high-rise apartments and stair-climbing competency is an important prerequisite for discharge.

The author who was not involved in the original surgical procedures or subsequent management of these patients performed all clinical data retrieval. The clinical measures studied included VAS pain scores, time to ambulation, knee range of motion at discharge, hospital LOS and complications. Statistical analysis was performed using the Mann Whitney Test and a multivariate regression model with the level of significance set at $p = 0.05$ for all analyses.

RESULTS

There were a total of 58 primary total knee arthroplasties in 56 patients with patients receiving either SFNB or CFNB. Two patients in this study had staged bilateral total knee arthroplasty in that 12-month study period. The mean age at the time of surgery was 64.8 years (range, 40- 86y) and the cohort was comprised of 43 females and 13 males. The preoperative diagnoses recorded were osteoarthritis (95%) and rheumatoid arthritis (5%). Preoperative risk stratification using the American Society of Anesthesiology (ASA) score revealed that 86% of the patients were ASA grade 2; 7% were ASA grade 1; and, 7% were ASA grade 3.

Table I: Total Knee Arthroplasty patient demographics for the two study groups (SFNB = single shot femoral nerve block; CFNB = continuous femoral nerve block)

	SFNB	CFNB
Patients (n)	25	29
Male	5	8
Female	20	21
Mean Age (years)	66.1	65.8
Mean Body Mass Index (kg/m2)	27.8	26.0

Table II: Means of clinical outcome measurements (* = statistically significant)

	SFNB (n=25)	CFNB (n=29)	Statistical significance
Pain at rest	1.0	0.7	P= 0.048 (*)
Pain with mobilisation	4.0	2.9	P= 0.047 (*)
Drain output	588.5mls	691.8mls	P= 0.192
Time to rescue analgesia	58 mins	6.2 hours	P= 0.029 (*)
Length of Hospital Stay (days)	7.8	7.2	P= 0.467

Table III: Mean functional outcome measurements (* = statistically significant)

Time to walking frame	3.2 days	2.6 days	P= 0.199
Time to independent ambulation	4.8 days	4.1 days	P= 0.017 (*)
Time to staircase competency	5.6 days	5.0 days	P= 0.069
ROM at discharge	85o	87o	P= 0. 455
Maximum Ambulation Distance	26.2m	26.4m	P= 0.630

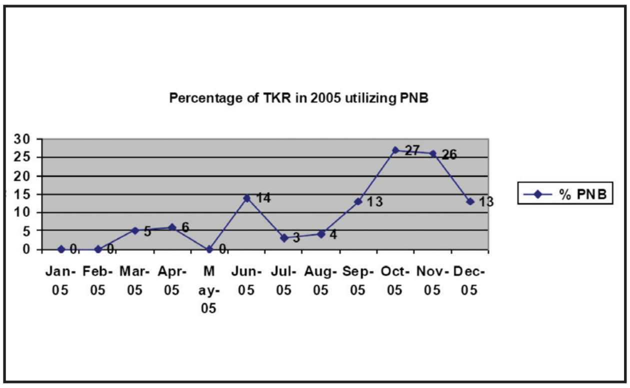

Fig. 1: Trends in use of PNB for TKA in the present study
PNB = Peripheral Nerve Block;
TKA = Total Knee Replacement

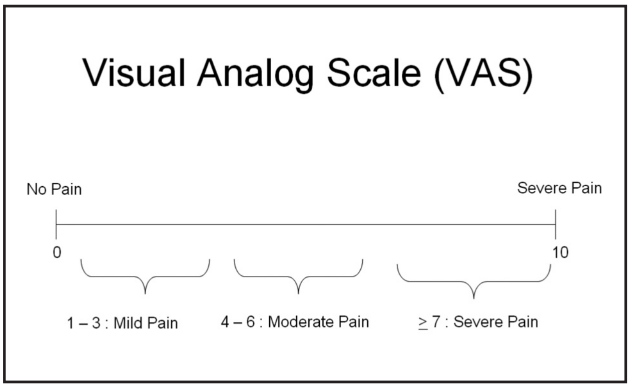

Fig. 2: Visual Analogue Scale (VAS) as used in the study.

There were 25 patients in the SFNB and 29 patients in the CFNB group. All SFNB patients had intravenous PCA set-up by the anaesthetist in the postoperative recovery unit following the surgical procedure. The patient demographics amongst the 2 study groups were comparable for gender, age and body mass index (Table I). The mean duration for administration of peripheral nerve block was 40 minutes (range, 10- 110min). The average duration for CFNB administration was longer at 46.5 minutes than the average time taken for SFNB administration of 32.0 minutes.

The mean time to first dose of oral rescue analgesia in patients on continuous catheter blockade was on average 6.2 hours (range, 20mins - 24hours), whereas the mean time to first dose of PCA use in patients on single shot blockade was 58 minutes (range 10min-3.5 hrs). The various clinical and functional outcome measures in the postoperative period are summarized in Table II and III for both study groups.

The VAS scores both at rest and with mobilisation were lower in the CFNB group as compared to the SFNB group. Patients on CFNB were found to progress to independent ambulation earlier than patients on SFNB (p=0.017). However, patients with CFNB had a slightly higher drainage output (probably due to the venous vasodilation effects of the administered infusion) when compared to the SFNB patient, but this was not statistically significant.

There was no a statistically significant difference in the LOS between the two groups ($p=0.467$). Using a robust multivariate regression model, the following factors were noted to increase LOS in the overall study group: age of the patients ($p<0.01$); diabetes mellitus (p: 0.018); and postoperative DVT ($p<0.01$). Two patients in the SFNB group and 4 patients in the CFNB group were diagnosed and treated for DVT. However, the Fisher Exact Test showed no significant difference in DVT between these two groups.

Complications specific to peripheral nerve blocks were related to nerve block catheters used in the CFNB group. There was one case of catheter breakage, two cases of catheter dislodgement and one case of catheter malpositioning. The catheter breakage occurred near the clamp at the time of removal of the CFNB meaning that there were no problems in the initial postoperative period during infusion. The incidents of catheter dislodgement occurred on 3rd POD, the day that CFNB was scheduled for discontinuation. The case of malpositioning was noted on the 1st POD and this case was subsequently excluded from the study cohort. In the SFNB group there were PCA related side effects: nausea (3 cases); vomiting (4 cases); and, acute urinary retention necessitating bladder catheterization (3 cases). There were no incidences of heel ulcers in either patient group. All patients were reviewed at 2 weeks following the index procedure and were noted to be ambulating well. There were no wound complications in either study group.

DISCUSSION

Postoperative knee range of motion is a very important outcome index for a successful TKA [16]. Many variables have been reported to be strongly correlated with postoperative knee range of motion such as: preoperative range of motion; use of CPM; preoperative degree of deformity; and, time to initiate rehabilitation [7,17]. With appropriate preoperative planning and surgical techniques, most patients attain satisfactory postoperative clinical outcomes. However, pain following total knee arthroplasty can be a significant rate-limiting step for time to successful rehabilitation. Consequently, delayed rehabilitation increases the risk of arthrofibrosis development with eventual risk of knee stiffness and reduction in knee scores following TKA [18].

Optimization of postoperative pain control significantly improves functional recovery and decreases hospital LOS after TKA [13,15,19]. Unilateral peripheral nerve blocks provide analgesia quality and functional outcomes similar to that of continuous epidural analgesia and superior to that of systemic intravenous opioid analgesia, but with fewer side effects [20]. Both SFNB and CFNB have been shown to be effective modalities as postoperative analgesia [15, 21-23].

Varied previous publications report on the use of peripheral nerve blocks in TKA.(10-12) To date, none have reviewed in detail the immediate postoperative outcomes of TKA patients as well as complications pertaining to the use of SFNB or CFNB. In the present study, CFNB utilization resulted in overall decreased pain scores both at rest and during mobilisation. There is concern that continuous nerve blocks may result in muscle weakness thus extending the rehabilitation and LOS periods. However, our study shows that the CFNB patients achieved independent ambulation more rapidly than SFNB patients. Moreover, there were no statistically significant differences in the LOS for the 2 study groups. The average LOS in CFNB patients (7.2 days) was, in fact, slightly shorter than the average LOS SFNB plus PCA patients (7.8days); but not to a statistically significant ($p=0.467$) degree.

In a recent study by Salinas et al, similarly improved pain scores were noted in CFNB patients.[24] The same study, however, reported no difference in hospital LOS or long-term functional recovery (knee flexion at 6 weeks and 12 weeks post surgery) between CFNB and SFNB patients. With the appropriate CFNB dosing regimens, optimal pain control may be achieved without the trade-off of muscle weakness. This facilitates early and improved range of motion, which in turn permits earlier independent ambulation. Though, the long-term functional recovery may not differ significantly between the two groups, the return to functional activities can be expected to be more rapid in the CFNB group as reflected in our results for time to independent ambulation (Table III).

Length of hospital stay translates directly into hospital costs and impacts on our health economy. Various measures, including the use of clinical pathways have been shown to accelerate postoperative recovery and thus decrease LOS [25,26]. Though there were no significant differences in LOS between our two study groups we were concerned if the LOS in patients undergoing peripheral nerve blocks was longer than patients given conventional pain control regimens. Though it was not the primary intent of the study, the mean LOS of TKA patients without peripheral nerve block was examined in the same 12-month period and it was noted to be 7 days. There was no significant association between LOS and peripheral nerve block ($p=0.17$, multivariate robust regression model)meaning for example that patients with peripheral nerve block (either SFNB or CFNB) did not have extended LOS when compared to patients with conventional postoperative analgesia.

Peripheral nerve block is now an established procedure that is offered to all TKA patients at the authors' institution. Placement of these femoral catheters requires additional skill, time and postoperative management. Since it is a teaching hospital, this procedure is being taught to anaesthesia residents at our institution. Further, the administration of a peripheral nerve block requires special skill acquisition compared to a spinal or general anaesthesia. In combination, these factors account for the extended total anaesthesia time for a routine TKA.

Despite the advantages of peripheral nerve blocks, there are noteworthy issues pertaining to this procedure. In the present study, there seems to be a slightly increased incidence of DVT with the use of nerve blocks and in particular in patients with CFNB. The use of peripheral nerve blocks is also associated with increased drain output, especially with CFNB. However, previous studies have noted that there are no added advantages with the routine use of drains in TKA[27,28]. It is probable that the venous vasodilation effects of peripheral nerve blocks increase the drain output and risk of DVT in TKA patients. Presently, drains are routinely removed on the 3rd POD in TKA patients (with peripheral nerve blocks) and most surgeons administer postoperative LMWH to decrease the risk of DVT. Though statistical analysis of DVT and bleeding occurrence in relation to CFNB patients showed no significant difference, this may be attributable to a small sample size. The authors are currently reviewing these variables using a prospective study with a larger sample size.

There is also potential for catheter site infection and nerve injury. A previous study reported a 57% rate of bacterial colonization in extracted catheters[29]. In the present study, there were isolated cases of catheter complications such dislodgement, malpositioning or tip breakage during removal. There were, however, no instances of prolonged nerve palsies or catheter site infection. There have also been reported incidences of heel ulcers following peripheral nerve block due to the sensory blockade[30,31]. There were no such complications in our study cohorts, but the routine use of heel protectors is strongly recommended and practiced at the authors' institution.

CONCLUSION

In conclusion, in TKA patients, enhanced postoperative pain control with improved rehabilitation is provided by CFNB as opposed to SFNB. Continuous peripheral nerve blockade should be strongly considered as an important postoperative adjunct in optimizing functional outcome following knee arthroplasty.

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