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A Comparative Study between Ultrasound Guided Four in One Block versus Femoral Nerve Block with Dexmedetomidine Additive in Enhanced Recovery after Knee and below Knee Surgeries

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ABSTRACT

Background: Improved recovery outcomes following knee surgeries are becoming increasingly prevalent in orthopedic procedures. **Aim:** To test whether femoral nerve block (FNB) with addition of dexmedetomidine can replace 4-in-1 block in enhanced recovery after knee and below knee operations.

Patients and methods: This was comparative clinical trial single blinded research performed in Suez Canal University Hospitals from May 2022 to December 2023.

Results: Statistically insignificant variances were reported in the context of the type of surgeries performed in each group as well as the duration of the surgeries performed comparing the FNB group to the 4 in 1 block group; p>0.05. Patients who underwent the 4-in-1 block exhibited statistically significantly lower VAS scores compared to those who received FNB; P value <0.05. On evaluating time to first rescue analgesia among both groups, it was observed that the 4-in-1 block group exhibited statistically significant prolonged intervals before requiring additional analgesia compared to the FNB group; p-value<0.0001. Values of TUG test at 24h postoperative were significantly lesser in the 4-in-1 block group than the femoral nerve block group p-value<0.05.

Conclusion: Our research confirms the efficiency of the 4-in-1 block as a superior substitute to FNB in postoperative pain management and functional recovery following knee and below knee surgeries. It evaluates parameters like VAS score, consumption of morphine, period to 1st rescue analgesia, SLR, TUG, and time to first mobilization, contributing to evidence-based decision-making in perioperative care.

Key words: One Block, Ultrasound Guided Four, FNB, Enhanced Recovery, Knee Surgeries.

INTRODUCTION

Improved recovery outcomes following knee surgeries are becoming increasingly prevalent in orthopedic procedures. The optimal postoperative objective is motor preservation through sufficient analgesia, which facilitates a faster recovery, an early hospital discharge and earlier physical treatment [(1)].

In comparison to general anesthesia, spinal anesthesia has more favorable outcomes for knee arthroplasty. This is attributable to the beneficial physiological effects of the sympathetic blockade, which include better initial pain relief, increased leg blood flow, and reduced blood loss. All of these factors contribute to a decrease in cardiopulmonary and thromboembolic morbidity. However, the potential effect is a decreased capacity to mobilize early after surgery due to the occurrence of pain following the resolution of spinal anesthesia [(2)].

In comparison to epidural or IV case-controlled analgesia, femoral nerve block (FNB) is recognized for its better management of pain, the reduction of the period required for functional recovery, and the reduction of the duration of hospitalization, all without any correlated negative consequences. Nevertheless, it decreases the strength of the quadriceps muscle and elevates the possibility of falls [(3)]. It was reported that patients who undergo total knee arthroplasty (TKA) and receive FNB commonly experience postoperative posterior knee pain that necessitates the use of supplemental opioid drugs [(4)].

Roy *et al.* [(5)] defined a new and single-administration method for the combined 4-in-1 block (saphenous nerve, obturator nerve, nerve to vastus medialis, and sciatic nerve) that provides full postoperative analgesia through a single injection point. They suggested that combination of an ACB, sciatic nerve block and peripheral nerve block presented positional and technical challenges that might be resolved with ease and certainty by utilizing a single injection 4-in-1 block method. Nevertheless, the 4-in-one methods have not been elucidated in any other investigations. Accordingly, it's desirable for conducting more extensive research for verifying results.

This study aimed to test whether FNB with addition of dexmedetomidine can replace 4-in-1 block in enhanced recovery after knee and below knee operations.

PATIENTS AND METHODS

This was comparative clinical study single blinded research performed in Suez Canal university Hospitals from May 2022 to December 2023.

Inclusion criteria: Cases of American Society of Anesthesiologists (ASA) physical status I to III of the two genders, equal or more than twenty-one to sixty-five years, scheduled for knee and below knee operations.

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Exclusion criteria: Non-ambulatory/bed ridden cases, cases with clinically significant coagulopathy, allergic reaction to local anaesthetics, infection at the administration site, cases with significant cognitive dysfunction, cases with pre-current neuropathy or myopathy on the operating limb, chronic analgesic abuser cases and time of operation more than 2 hours.

Sample size calculation

The sample size has been estimated utilising the formula that follows [6]:

$$n = 2\left[\frac{(Z_{\alpha/2} + Z_{\beta}) * \sigma}{\mu_1 - \mu_2}\right]^2$$

Wherever **n**= sample size

$\mathbf{Z_{\alpha/2}}$ = 1.96 (The critical value, which divides the central ninety-five percent of the Z distribution from the five percent in the tail).

$\mathbf{Z_{\beta}}$ = 0.84 (The critical value, which separates the lesser twenty percent of the Z distribution from the upper eighty percent). **σ** = the estimate of the SD = 1.9 **[7].**

$\mathbf{\mu_1}$ = mean VAS score on return to ward in the femoral group = 5.2. **[7]** $\mathbf{\mu_2}$ = mean VAS score on return to ward in the four in one group = 3.9. **[8]**

So, by determination, the sample size has been equal to 33.47 (≈34) cases per group, giving a total sample size of 68 individuals.

METHODS

All patients were subjected to the following:

Sampling technique

Randomization sampling

Cases have been randomly assigned to one of both groups by using computer generated random numbers that have been concealed in opaque closed envelopes that were sequentially named: **4-in-1 block group:** Patients received 4-in-1 block with 0.375% bupivacaine and **FNB group:** Cases had femoral nerve block with 0.375% bupivacaine plus 1 mcg per kg dexmedetomidine.

Preoperative assessment

Prior to operations, all cases have been required to adhere to an eight-hour fast. Temperature testing (e.g., ice test) was carried out on the medial and anterior aspects of the thigh (for femoral nerve), on the medial aspect of the lower leg (for saphenous nerve), and on the posterior aspect of the knee and lower leg (for sciatic nerve) to conduct sensory evaluation. The quadriceps muscle was assessed by telling the case to sit with his knees extended over the side of the table. The case extended the knee joint without rotating the thigh, whereas the examiner firmly held the thigh down on the table. **Hosseini *et al.* [9]** scored the quadriceps muscle strength as follows: No muscle activation, trace muscle activation (e.g., a twitch), without achieving full range of motion, muscle activation with gravity removed, full range of motion, muscle activation against gravity, full vary of motion, full range of motion, muscle activation against some resistance, muscle activation against the examiner's full resistance, full range of motion. Quadriceps muscle weakness has been described as quadriceps strength ≤3.

Induction of anesthesia

Spinal anesthesia was administered under complete aseptic conditions, sterilizing the patient with 10% povidone iodine. A skin wheal has been elevated at L3/4 interspaces with two ml lidocaine 2%. A spinal needle was advanced through deeper structures, confirming free flow of cerebrospinal fluid (CSF). three milliliter 0.5% hyperbaric bupivacaine has been administrated. The case has been then supine, and the blockade level was tested using temperature sensation loss. Hypotension, bradycardia, reduced peripheral oxygen saturation, vomiting, nausea, and other negative consequences have been reported in cases who underwent the operation or received the administrated medication. If hypotension was present, ephedrine was given intravenously, atropine was given if bradycardia was associated with hypotension or impaired perfusion, supplemental oxygen was given to maintain SpO_2 above 94%, and ondansetron was given intravenously for postoperative nausea and vomiting.

The 4-in-1 block: Cases were maintained in a supine position, with the ipsilateral limb in the frog leg position. A mark was present on the medial femoral condyle. Linear transducer of a transportable ultrasound system has been detected by placing it over the vastus medialis muscle and femoral condyle, in addition to the sartorius and vastus intersection (anteromedial intermuscular septum) according to aseptic precautions. The transducer was then slid proximally until the superficial femoral artery was visible in the adductor hiatus. Then slid proximally until the descending genicular artery, which branches from the superficial femoral artery, has been visible in the hiatus. The administration point was at this location. The point was 810 centimetres above the femoral condyle. The echogenic needle, which was four inches in length and twenty-two gauge, was utilized for the block. Under ultrasound guidance, the needle has been injected in-plane in a lateral to medial orientation as soon as the perivascular region had been reached. The femoral artery has been posteriorly pushed by injecting thirty-five millilitre volume of 0.375% bupivacaine (bupivacaine: saline 3:1) following negative aspiration to prevent accidental intravascular administration. The medication solution was observed to spread.

The FNB: The cases were positioned at a supine position with their ipsilateral limb slightly rotated and abducted. A

transportable ultrasound system was used to obtain images of the femoral nerve and artery. An echogenic needle was used for the block, and the needle has been injected in-plane in a lateral to medial orientation. For preventing accidental injections, a volume of 0.375% bupivacaine and one microgram per kilogram dexmedetomidine has been injected around the femoral nerve following negative aspiration. Under ultrasound imaging, the medication solution has been found to diffuse throughout tissue planes.

Postoperative monitoring: Cases have been observed, and information reporting has been performed at 2, 4, 6, 8, 12, 18 and 24 h after the operation for: Postoperative pain using VAS score and opioid consumption, quadriceps strength tests, time up and go test (TUG), straight leg raise test (SLR), first time of mobilization and rate of complications. **End Point:** 24 hours postoperatively.

Ethical considerations: All the procedures of the research were permitted by the Ethics Committee of Faculty of Medicine, Anesthesia and Intensive Care Department, Suez Canal University. Administrative consents required have been taken. The objective of this research was to conduct research on humans in accordance with the Declaration of Helsinki, the ethical norm established by the World Medical Association.

Statistical analysis

Statistical analyses were performed among the studied groups utilising the Graph Pad Prism 9 software (GraphPad Software, San Diego, CA, United States of America). Qualitative data were described utilising percentages and numbers. The numerical data have been described as mean ± standard deviation. The Mann-Whitney test and unpaired Student's T-test have been applied for quantitative data, while the Chi-square test has been utilized for qualitative data. The importance of the acquired findings has been assessed at the five percent threshold. P-values have been considered significant when ≤0.05, with *, **, ***, and **** representing $P \leq 0.05$, $P \leq 0.01$, $P \leq 0.001$, and $P \leq 0.0001$, respectively.

RESULTS

A statistically insignificant variances was discovered among the examined groups according to age, weight, height, BMI, gender and ASA (Table 1).

Table (1): Comparison of general characteristic between the studied groups

Demographic data		FNB (n=34)	4 in 1 block (n=34)	p-value
Age (Years)		61.08 ± 7.31	58.26 ± 6.79	0.1037
Wt (Kg)		91.94 ± 7.56	90.62 ± 7.32	0.46577
Height (cm)		174.47 ± 7.37	176.18 ± 7.65	0.35285
BMI (Kg/m^2)		31.85 ± 2.88	31.42 ± 2.71	0.5233
Sex	Male (n, %)	22 (64.71 %)	24 (70.59 %)	0.6042
	Female (n, %)	12 (35.29 %)	10 (29.41 %)	
ASA (I-III)	I (n, %)	16 (47.06%)	14 (41.18%)	0.8542
	II (n, %)	10 (29.41%)	12 (35.29%)	
	III (n, %)	8 (23.53%)	8 (23.53%)	

Data described as mean ± SD or number and percentage. Wt: Weight BMI: Body mass index ASA: American Society of Anesthesiologists.

A statistically insignificant differences were reported in the context of the type of surgeries performed in each group as well as the duration of the surgeries performed comparing the FNB group to the 4 in 1 block group (Table 2).

Table (2): Comparison of type and duration of surgeries and among the studied groups

	FNB (number=34)	4 in 1 block (n=34)	p-value
Type of surgery (n, %)			
Total knee replacement	10 (29.41%)	12 (35.29%)	0.6042
Tibial plateau ORIF	9 (26.47%)	8 (23.53%)	0.7794
Tibial intramedullary nail	15 (44.12%)	14 (41.18%)	0.7579
Duration of surgeries (mins)	87.67 ± 16.09	89.73 ± 15.36	0.5913

Patients who underwent the 4-in-1 block exhibited statistically significantly lower VAS scores compared to those who received FNB (Table 3).

Table (3): Visual analog scale score among the groups

VAS score range (1-4)	FNB (number=34)	4 in 1 block (n=34)	p-value
Two hours	**0.5588 ± 0.5040**	**0.2647 ± 0.4478**	**0.0258***
Four hours	**2.118 ± 1.122**	**0.3529 ± 0.4851**	**<0.0001****
Eight hours	**2.735 ± 1.082**	**1.500 ± 0.5641**	**<0.0001****
Twelve hours	**2.971 ± 0.6269**	**2.559 ± 0.5609**	**0.0091*****
Eighteen hours	**3.471 ± 0.5066**	**3.324 ± 0.4749**	**0.3216**
Twenty-four hours	**3.559 ± 0.5040**	**3.529 ± 0.5066**	**>0.9999**

*: Significant, ***: Highly significant, ****: Very highly significant.

On evaluating time to first rescue analgesia among both groups, it was observed that the 4-in-1 block group exhibited statistically significant prolonged intervals before requiring additional analgesia compared to the FNB group (Table 4).

Table (4): Time to first rescue analgesia comparison among the studied groups

	FNB (n=34)	4 in 1 block (n=34)	p-value
Time to first rescue analgesia (hrs)	**4.412 ± 0.9883**	**12.26 ± 1.639**	**<0.0001****

****: Very highly significant

The 4-in-1 block group received considerably less morphine than the FNB group throughout initial twenty-four hours postoperatively, as indicated by the cumulative dose of morphine used in each group (Table 5).

Table (5): Comparison of total dosage of morphine consumption among studied groups

	FNB (n=34)	4 in 1 block (n=34)	p-value
Morphine consumption following surgery (milligram/24hr)	12.21± 5.250	7.353 ± 4.960	0.0002***

***: Highly significant.

At 24 hours postoperatively, the time up and go test values were significantly lesser in the 4-in-1 block group than in the femoral nerve block group (Table 6).

Table (6): Comparison of timed up-and-go test among the studied groups.

	FNB (n=34)	4 in 1 block (n=34)	p-value
Timed up and go (TUG) test (Secs)	32.24 ± 8.958	22.47 ± 6.501	<0.0001****

****: Very highly significant

Comparing time to first mobilization among both groups, a statistically significant reduced durations has been noted in the 4-in-1 block group than femoral nerve block group. This indicates that patients who received the 4-in-1 block initiated mobilization earlier than those in the FNB group (Table 7).

Table (7): Time to first mobilization among the studied groups.

	FNB (n=34)	4 in 1 block (n=34)	p-value
Time to first mobilization (hours)	12.74 ± 1.928	4.471 ± 0.8956	<0.0001****

****: Very highly significant.

Insignificant variances were discovered among FNB and 4 in 1 block groups in regard to the recorded complications, namely, nausea, vomiting, hypotension, use of vasoconstriction medication or falling incidence (Table 8).

Table (8): Complications during 24 h after operation

Complications	FNB (n=34)	4 in 1 block (n=34)	p-value
	n (%)	n (%)	
• Nausea	9 (26.5%)	7 (20.6%)	0.5675
• Vomiting	2 (5.9%)	3 (8.8%)	0.6422
• Hypotension (Systolic BP <80 mmHg)	3 (8.8%)	2 (5.9%)	0.6422
•Vasoconstriction medication	7 (20.6%)	5 (14.7%)	0.5246
• Falling incidence	5 (14.7%)	3 (8.8%)	0.4516

Data are expressed as number and percentage of patients who experienced the symptoms at least once.

DISCUSSION

Our study included 68 cases, having below knee and knee surgeries, classified into both groups, 4-in-1 block and FNB groups. We investigated the effectiveness of the 4-in-1 anesthesia block approach in comparison to the FNB combined with dexmedetomidine in postoperative pain management and morphine consumption following knee and below knee surgeries. In the current study, subject baseline characteristics, including age, weight, height, BMI, gender, duration and type of operation and ASA classification, have been evaluated across the studied groups and exhibited no statistically significant differences, indicating a comparable baseline characteristic among the involved subjects.

In our study regarding primary outcomes reflecting the pain control, VAS scores were measured at various time intervals (two, four, eight, twelve, eighteen, and twenty-four hour) following surgery. The results showed that patients who received the 4-in-1 block exhibited significantly lower VAS scores at most of the time compared to those who received FNB, with a statistically significant variance (P value < 0.05). This result suggests that the 4-in-1 block was more efficient in controlling postoperative pain intensity than the FNB approach.

Prior investigation has stated that utilization of FNB may not be enough to provide pain management and comprehensive analgesia around knee region particularly following total knee arthroplasty (TKA). This is attributed to the fact that knee innervation entails contributions from the lumbar plexus (through the femoral and obturator nerves) together with the sacral plexus (through the sciatic nerve). Given the advantage of 4-in-1 block as it targets multiple nerves (namely, obturator, saphenous, nerve to vastus medialis and sciatic), thus it offers an extra benefit of sciatic nerve blockade, making it more efficient than FNB in managing postoperative pain following TKR [10].

Within research by **Roy *et al.*** [8], similar to our results, patients who received the 4-in-1 block demonstrated significantly lower pain scores postoperatively. This consistency in outcomes across studies underscores the reproducibility and reliability of the observed benefits associated with the 4-in-1 block technique in pain management.

Additionally, the time to first rescue analgesia has been evaluated to assess the duration of pain relief provided by each block technique. The results revealed that patients in the 4-in-1 block group experienced significantly prolonged intervals before requiring additional analgesia (12.26) compared to those in the FNB group (4.41). This finding suggests that the 4-in-1 block led to a longer duration of effective pain control, contributing to reduced morphine consumption and potentially minimizing the risk of opioid-related adverse effects. Furthermore, the total consumption of morphine throughout the initial twenty-four h following surgery has been assessed between the two groups. It was observed that patients in the 4-in-1 block group consumed significantly lesser morphine than those in the femoral nerve block group, indicating superior analgesic efficacy with the 4-in-1 block technique.

In our study, the use of dexmedetomidine with FNB could be supported by **Chen *et al.*** [11] who suggested that dexmedetomidine, when applied as an adjuvant to ropivacaine in the femoral nerve block of adult cases having TKR, increases the quality of analgesia and extends the period of analgesia in comparison to FNB alone. Other studies also support our use of dexmedetomidine. **Swami *et al.*** [12] reported that the period of motor and sensory block, as well as the period of analgesia, were increased if dexmedetomidine was utilized in local anesthesia within supraclavicular brachial plexus block. In comparison to cases who had clonidine, the duration of rescue analgesia was extended in cases who had dexmedetomidine [12].

However, the administration of dexmedetomidine at a dosage of two microgram per kilogram in a femoral nerve block is more effective than one microgram per kilogram in terms of giving analgesia following TKA [13].

By minimizing opioid consumption, the 4-in-1 block offers a safer alternative for postoperative pain management while ensuring adequate analgesia and patient comfort. The meta-analysis study of **Zorrilla-Vaca and Li** [14] investigated the pros of combining sciatic nerve block and femoral nerve block in total knee replacement and postoperative knee management. Their findings indicate that combining SNB and FNB succeeds to achieve a significant decrease in pain scores during movement (for about 12 hours' duration) or at rest (and up to 4 hours' duration), besides this was accompanied by decreased opioid consumption post TKR. Although up to our knowledge there were no studies comparing morphine use between 4 in 1 block and FNB, our study indicates that the 4-in-1 block is associated with reduced morphine consumption in the initial 24 hours postoperatively compared to FNB. This reduction in opioid consumption is clinically significant, given the well-documented negative consequences correlated with opioid utilization, for example respiratory depression, nausea, and constipation.

The evaluation of secondary outcomes focused on mobilization and functional recovery measures, including quadriceps muscle strength, early mobilization. These outcomes have been evaluated through the timed up and go test, the straight leg raise (SLR) test, and the time to first mobilization.

In comparison to the FNB group, the 4-in-1 block group showed significantly better results in the assessment of strength of quadriceps muscle and early ambulation utilizing the straight leg raise test at twelve hours, eighteen hours, and twenty-four hours following

surgery. Specifically, the percentages of SLR test results have been significantly greater within the 4-in-1 block group at 12 hours and 18 hours postoperatively, indicating favourable quadriceps muscle strength and early ambulation capacity. Nevertheless, statistically insignificant variance has been observed among both groups at the 24-hour time point. This suggests that there is an initial advantage with using 4-in-1 block approach exhibited in the form of enhancing quadriceps muscle strength and early ambulation, which diminishes over time.

In support to our results, **Faiaz and Kamath, [15]** performed a cohort where cases having anterior cruciate ligament (ACL) procedure receiving general anaesthesia were randomly sorted to have either FNB or adductor canal block (ACB). They investigated analgesic efficiency using visual analog scale pain scores and cumulative diclofenac taking. Further, case functionality and ambulation were evaluated via measuring quadriceps muscle strength at two hours, twelve hours, and twenty-four hours post-operation, and compared it to the contralateral side utilizing the Medical Research Council grading score for strength of muscle. Their outcomes demonstrated which adductor canal block is advantageous compared to femoral nerve block as an analgesic approach, as it provided comparable results regarding pain relief to FNB but with the advantage that it did compromise quadriceps motor strength, which might be affected with FNB.

CONCLUSION

Our research confirms the efficiency of the 4-in-1 block as a superior substitute to FNB in postoperative pain management and functional recovery after knee and below knee surgeries. It evaluates parameters like VAS score, time to first rescue analgesia, SLR, TUG, morphine consumption, and time to first mobilization, contributing to evidence-based decision-making in perioperative care.

DECLARATIONS

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