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ORIGINAL ARTICLE

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A comparative study between continuous epidural analgesia, ultrasound guided continuous femoral nerve block (CFNB), and ultrasound guided continuous adductor canal block (ACB) for post-operative pain management after total knee replacement (TKR)

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Abstract

Background Total knee replacement (TKR) is considered a prevailing cause of severe postoperative pain and discomfort among orthopedic surgeries, limiting postoperative ambulation that is important for regaining joint function. Despite being the gold standard, epidural analgesia can be accompanied by diverse complications delaying postoperative ambulation and discharge from hospital. Continuous femoral nerve block (CFNB) and continuous adductor canal block (ACB) are reliable and efficacious regional anaesthesia techniques allowing better control of postoperative pain. This study purposed to compare epidural analgesia, continuous femoral nerve block & continuous adductor canal block regarding postoperative analgesia & incidence of postoperative complications.

The aim of this study is to estimate the efficacy of epidural analgesia, continuous femoral nerve block & continuous adductor canal block regarding postoperative pain control following total knee replacement and the rate of incidence of associated postoperative complications.

This is a prospective randomized controlled study where sixty patients were randomized into three equal groups, patients in group A received epidural analgesia, patients in group B received continuous femoral nerve block while patients in group C received continuous adductor canal block with postoperative continuous infusion of 0.125% bupivacaine with fentanyl 2μg/ml in the three groups at a rate of 5 ml/hr. VAS score was assessed for 48 hours postoperatively and complications were recorded.

Results Epidural analgesia was superior to CFNB and ACB regarding postoperative pain control using visual analogue scale and postoperative pain control. CFNB and ACB are superior to epidural analgesia regarding postoperative ambulation and postoperative complications.

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Conclusions Continuous epidural analgesia provides superior analgesia following total knee replacement than femoral nerve block and adductor canal block, with relatively more adverse effects like pruritus, post operative nausea, and vomiting (PONV). Both CFNB and ADB are good alternatives with fewer systemic side effects.

Trial registration ClinicalTrials.gov Identifier: NCT 05249478.

Keywords Epidural analgesia, Femoral nerve block, Adductor canal block, Total knee replacement

Background

Total knee arthroplasty (TKA) is a highly agonizing surgery with a considerable possibility for complications, not only related to the surgical impact of the procedure but also related to demographic and clinical characteristics of the target patients. Ideal postoperative pain control methods following surgery are directed to provide adequate pain relief with the least opioid consumption and to preserve motor strength to hinder postoperative complications. The implementation of multimodal methods including regional anaesthesia is broadly used to encounter such expectations (Bauer et al. 2014).

Epidural analgesia is one of the postoperative analgesic modalities that may produce a superior analgesic effect compared with systemic opioids, whilst precluding the adverse effects of systemically administrated opioids. Using epidural opioid analgesia markedly improves postoperative pain when compared with opioid patient-controlled analgesia (PCA), but unfortunately associated with a greater probability of pruritus (Khan et al. 2013).

Femoral nerve block is an alternative modality of pain control and shortening of the functional recovery period and hospital stay with relatively less accompanied side effects, compared to epidural or systemic intravenous (IV) patient-controlled analgesia (Wang et al. 2017).

With the aid of ultrasound guidance, the saphenous nerve, which is considered the terminal sensory branch of the femoral nerve, is to be blocked at the level of the mid-thigh within the adductor canal. There is growing literature on the effectiveness of adductor canal block, and the available evidence suggests that it is just as effective as femoral nerve block in relieving pain after knee surgery. Moreover, adductor canal block is favoured for minimally affecting the strength of quadriceps muscle, which facilitates ambulation and postoperative rehabilitation (Jæger et al. 2013).

The purpose of this study was to estimate the efficacy of epidural analgesia, continuous femoral nerve block & continuous adductor canal block regarding postoperative analgesia and the rate of incidence of associated postoperative complications.

Methods

Study protocol

Sixty patients of either sex who are older than 40 years and have a physical status of I to III according to the American Society of Anaesthesiologists (ASA) undergoing unilateral total knee replacements (TKR). A computer-generated random numbers table was used to divide the patients into three equal groups; each group had 20 patients, introduced into closed envelopes. The envelopes were opened in the induction room.

Patients received one of the following treatments:

1. Group A (epidural group): 20 patients who received continuous epidural analgesia.
2. Group B (femoral group): 20 patients who received continuous femoral nerve block (CFNB).
3. Group C (adductor): 20 patients who received continuous adductor canal block (ACB).

After receiving the assigned block according to each group, all patients in the three groups received spinal anaesthesia in the sitting position.

Exclusion criteria

Patients with major deformities affecting spine, bleeding disorders, and coagulopathy, history of local anaesthetics allergy, presence of injection site skin infection, pre-existing myopathic or neuropathic disorders, known cognitive disorders, patients were receiving long-acting opioids during the preoperative period and patient refusal to participate.

Study interventions

After detailed preoperative assessment and preoperative fasting for 8 hrs, Patients were monitored intraoperatively for blood pressure, heart rate, electrocardiogram (ECG), and pulse oximetry (SpO2) in accordance with ASA recommendations. The epidural catheter was placed before the administration of spinal anaesthesia in the sitting position, while femoral and adductor canal catheters were placed under ultrasound guidance in the supine position before the administration of spinal anaesthesia according to patient group allocation by a single operator (Figs. 1 and 2).

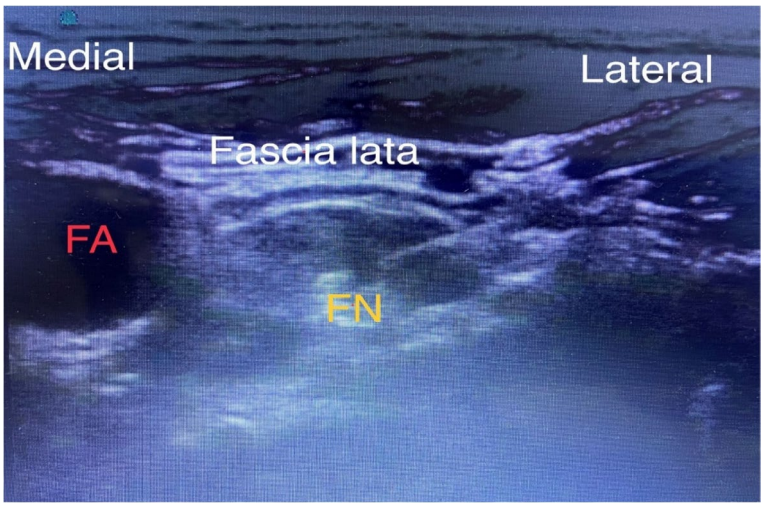

Fig. 1 Spread of local anaesthetic before femoral catheter advancement. Femoral artery (FA), Femoral Nerve (FN)

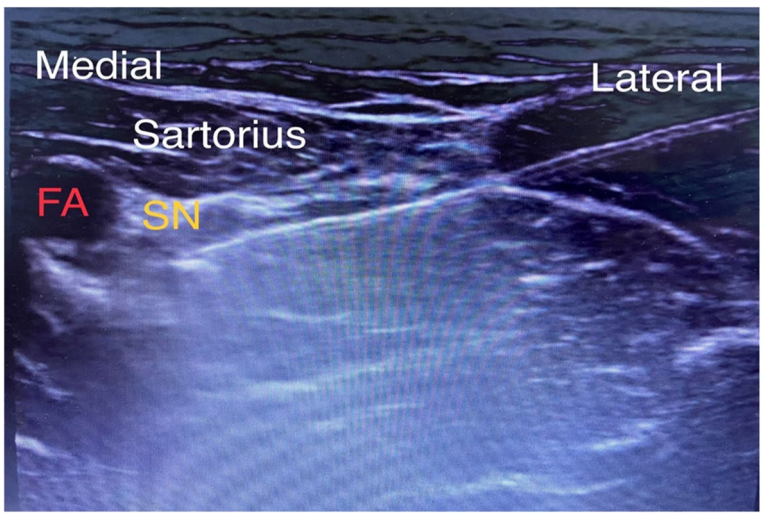

Fig. 2 Spread of local anaesthetic before catheter advancement in the adductor canal. Femoral Artery (FA), Saphenous Nerve (SN)

For the epidural group (group A)

After skin sterilization, the epidural needle was inserted between the lumbar vertebrae at level of L3-L4 or L4-L5 and the epidural catheter was inserted through the needle into the epidural space.

The epidural needle (18-gauge and 8.89 cm (3.5 inches) in length) was inserted in the midline of the patient's back, defined by the spinous processes at the chosen spinal level. Skin and subcutaneous tissue at the midline in the lower third to half of the interspace was infiltrated with 1% lidocaine by a 25-gauge needle and was continued through the supraspinous ligament down to the interspinous ligament. The epidural needle was inserted with stylet at a straight or slight cephalad angle or at a steeper cephalad angle. The needle bevel was oriented cephalad and advanced through the supraspinous ligament and into the interspinous ligament. A firmness in the tissue suggested that the needle tip was in the supraspinous or interspinous ligament. Lack of firmness indicated a paraspinous position, and the needle was adjusted.

Once the needle tip was anchored in the interspinous ligament, the confirmation of the proper position of the tip of the epidural needle in the epidural space was done a loss of resistance (LOR) technique using a syringe containing air. Intermittent or continuous gentle pressure was applied to the plunger with the dominant thumb while advancing the needle slowly with the

non-dominant hand. Once LOR occurs, needle advancement was stopped to avoid an unintentional dural puncture. A small amount of air (1 to 2 mL) was injected into the epidural space, avoid injecting larger amounts of air as this may contribute to patchy anaesthesia, a 3 ml solution of lidocaine 1.5 % and 1:200,000 epinephrine is used as a test dose. Acute onset tachycardia (20 to 30 beats above baseline) within one minute (intravascular insertion) or a dense motor blockage within five minutes of administration (intrathecal placement) are signs of a positive test dosage (Guay 2006).

For the femoral group (group B)

With complete aseptic precautions, using a portable Sonosite M-Turbo (Bothell, WA, USA) ultrasound system, the linear probe was placed on the femoral crease to localize the femoral nerve which is located lateral or posterolateral to the femoral artery at the level of the femoral triangle.

Eighteen Gauge, 3.5 inches echogenic needle was used. Before proceeding, skin was infiltrated with 5ml of 1% lidocaine, upon visualizing the femoral nerve, the needle was inserted using in-plane approach with advancing the needle in a lateral to medial orientation. Once the tip approached the nerve, the catheter was accessed through it, then the needle was removed, and the location of the catheter was confirmed by the catheter visualization and the spread of local anesthetic (LA). After the injection of 2 to 3 ml of LA through the needle under ultrasound guidance to confirm placement, the rest of the bolus was injected while visualizing the spread of LA. Securing the catheter to the skin was done with a sterile dressing after applying a sterile surgical glue.

For the adductor group (group C)

With complete aseptic precautions, using a portable Sonosite M-Turbo (Bothell, WA, USA) ultrasound system, the linear probe was placed vertically to the thigh, midway between the anterior superior iliac spine and the base of the patella, the adductor canal is roofed by sartorius muscle and bounded medially by adductor longus muscle and laterally by vastus medialis muscle.

Eighteen Gauge, 3.5 inches echogenic needle was used. Before proceeding, skin was infiltrated with 5ml of 1% lidocaine, the saphenous nerve was identified as it lies adjacent proximally lateral then distally superior to the femoral artery. More distally, the saphenous nerve becomes more superficial with an arterial branch just deep to sartorius muscle. using an in-plane approach, after negative aspiration, the tip of the needle was placed deep to the sartorius muscle, at the lateral border of the artery, Once the needle was in position, the catheter was introduced through it, then the needle was removed. 2 to 3 ml of LA was injected through the needle under ultrasound guidance to confirm placement and the rest of the bolus was injected through the catheter while visualizing the spread of LA. The catheter was secured to the skin with a sterile dressing after applying a sterile surgical glue.

For the spinal anesthesia

Spinal anaesthesia was delivered to all patients in sitting position, after receiving the assigned block according to group allocation, using a 25-gauge Quincke needle at the level of the L3-L4 or L4-L5 interspace, and at the same level of epidural catheter insertion in epidural group, along with 2.5 to 3 ml of 0.5% heavy bupivacaine and 25 mcg of fentanyl infused at a rate of 0.2 mL/second. The level was recorded when the sensory block was confirmed, and surgery was initiated.

The intraoperative management of the patients included monitoring for any complications including hypotension, bradycardia, desaturation, nausea, vomiting, or any other side effects as:

- Hypotension (defined as a 20% reduction of BP from baseline or systolic blood pressure <100 mmHg) and treated with 6 mg ephedrine and repeated every 3 minutes until resolution of hypotension (Morgan et al. 2001).
- Bradycardia (defined as either more than 30% decrease in HR compared with preanesthetic rate or HR less than 40 beats per minute and was treated with 0.5 mg of intravenous atropine (Ahn et al. 2016).
- Desaturation (defined as a reduction of oxygen saturation (SpO2) below 94% for more than 30 seconds, confirmed by good signal quality and no probe displacement (Siriussawakul 2014).
- nausea, vomiting and requirement of analgesic doses for the first 48 hours after the surgery were noted.

After the end of the surgery, continuous infusion of 0.125% bupivacaine with fentanyl 2μg/ml was initiated at a rate of 5 ml/hr using infusion pump in the three groups.

Postoperative pain was assessed after regaining sensation in the other limb by using visual analogue scale (VAS) which is presented as a 10 cm straight line reflecting the extremes of "no pain" and "worst pain." VAS more than 3 was managed by top up dose of 5ml.

A rescue dose of 3 mg morphine was given for relief of pain in case of persistent pain.

Outcome of study

The Primary outcome of this study was the evaluation of pain control using the Visual Analog Scale (VAS) score. Patients were observed, and data were recorded at 0,1,6,12,24,36 and 48 hours for postoperative VAS scores, while secondary outcomes were hemodynamic changes (mean blood pressure and heart rate) and side effects such as pruritis, nausea, vomiting, and requirement of analgesic doses for the first 48 hours after the surgery were noted.

Statistical analysis

Sample size

Was calculated using pass 11 power program, setting power at 80% and alpha error at 5%. Reviewing results from previous studies (Davies A.F. et al, 2004 and Chuan A. et al, 2019) showed that the mean VAS at 48 h postoperative for epidural analgesia versus femoral nerve block (FNB) versus adductor canal block (ACB) was (54 ± 16.6, 34.4 ± 12.6 and 47 ± 16). based on this a sample size of at least 60 (20 for each group) is needed (Ahn et al. 2016), (Siriussawakul 2014).

Statistical method

Statistical Package for Social Science (SPSS) version 22.0 for Windows was used to analyse data (SPSS, Chicago, IL, USA). Data were presented quantitatively as mean ± standard deviation (SD). Qualitative information was displayed as a percentage and a median (IQR). Quantitative parametric data from the three groups were compared using analysis of variance and post hoc testing. In cases where there was a substantial difference, Tukey's analysis was used. Chi square analysis was employed to compare qualitative data. The allowable margin of error was set at 5%, while the confidence interval was set at 95%. When the p-value was less than 0.05, the significance threshold was considered significant.

Results

Seventy-six patients were enrolled to participate in our study, 5 patients were excluded for not meeting inclusion criteria, 7 patients refused to participate, while 4 patients were excluded due to other causes (refusal of spinal Anesthesia) as shown in Fig. 3 (Tables 1, 2, 3, 4, 5 and 6)

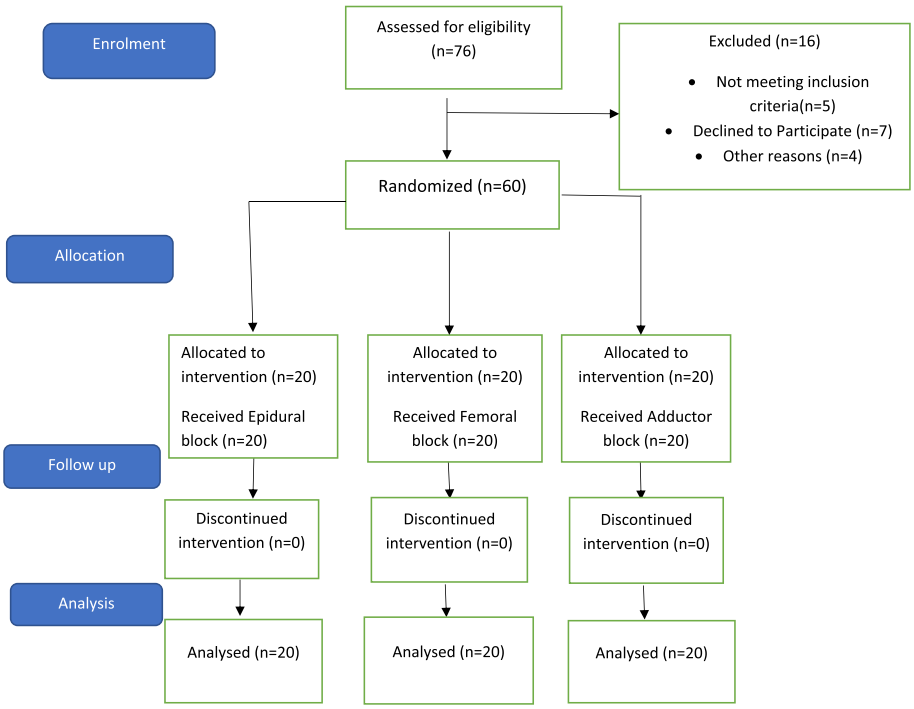

Fig. 3 Showing the total number of enrolled patients and allocated groups

Table 1 Comparison between the three study groups as regard demographic data

	Group A (*n*=20)	Group B (*n*=20)	Group C (*n*=20)	*p*-value
Age (years)	58.55± 4.5	58.8 ± 6.6	59.1± 6.08	0.95
Sex (M/F)	11/9	11/9	12/8	0.934
ASA				0.957
• I	7	8	9	
• II	7	7	7	
• III	6	5	4	
BMI	31.1± 1.2	31.25 ± 2.4	32.5 ± 2.12	0.082
Duration of surgery (in Minutes)	97.7± 5.17	101.65 ± 8.12	102.05± 5.75	0.072

Data are presented as mean ±SD

Demographic data (age, ASA, sex, duration of surgery, and BMI) was evaluated between the three groups, but no detectable statistical differences were found.

ASA American Society of Anaesthesiologists Physical Status, *BMI* Body Mass Index

P more than 0.05 was considered statistically non-significant

Table 2 Comparison between the three groups as regard the VAS score

	Group A (*n*=20)		Group B (*n*=20)		Group C (*n*=20)		A Vs B	*A vs C*	*B vs C*	*P value*
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**	*Mann Whitney U test*			
VAS 0 hr	1	1 (0-1)	1	1 (1-2)	2	1 (1-2)	0.01	0.001	0.285	0.001
VAS 1 hr	1	1 (1-2)	2	1(1-2)	2	1(2-3)	0.038	0.001	0.15	0.001
VAS 6 hrs	1	0(1-1)	2	1(1-2)	2	0(2-2)	0.007	<0.001	0.84	<0.001
VAS 12 hrs	1	1(0-1)	2	2(1-2)	2	0(2-2)	<0.001	<0.001	0.177	<0.001
VAS 24 hrs	1	0(1-1)	2	1(1-2)	2	0(2-2)	<0.001	<0.001	0.512	<0.001
VAS 36 hrs	1	1(0-1)	2	1(1-2)	2	0(2-2)	<0.001	<0.001	0.317	<0.001
VAS 48 hrs	1	0(1-1)	2	1(1-2)	2	1(1-2)	<0.001	<0.001	0.41	<0.001

Data are presented as median ±SD

VAS score was used to compare the three groups regarding postoperative pain control and was assessed at regular intervals (at PACU, 1hr,6hrs, 12hrs, 24hrs, 36hrs, and 48 hrs). The epidural group showed better pain control and lower VAS scores than both the femoral and adductor groups

IQR Inter quartile range, *VAS* Visual Analogue Scale

P<0.05 was considered statistically significant

Table 3 Comparison between the three groups as regard number of patients who received top-up doses

	Group A (*n*=20)	Group B (*n*=20)	Group C (*n*=20)	*p*-value
Number of patients who received top-up doses	2	6	9	0.047*

Using Chi square, *P*<0.05 was considered statistically significant between the 3 groups

Number of patients who received top up doses was lesser in the epidural group (group A) than in the two other groups

Discussion

Epidural group showed lower VAS scores compared to CFNB group, Also, the number of patients who received top up doses was lower in epidural group (2), than in the femoral group (6). This finding was supported by a trial conducted by *Sundarathiti et al.*, which was performed on 61 patients who underwent TKA, thirty-one patients received continuous epidural analgesia (epidural group) with continuous infusion of 0.125% levobupivacaine and morphine 0.0125 mg/ml (Sundarathiti et al. 2009).

In a double-blind, prospective, randomised controlled trial study on 200 patients, *Tan et al*. in 2018, found that

Table 4 Comparison between the three study groups as regard postoperative opioid consumption

	Group A (*n*=20)	Group B (*n*=20)	Group C (*n*=20)	*p*-value
Postoperative opioid (morphine) consumption (mg)	1.88± 1.5	3.58 ± 1.67	4.88± 2.21	<0.001

Data are presented as mean and standard deviation

Regarding postoperative opioid consumption, there was a statistical significance between the three groups with higher opioid consumption in both the femoral and adductor groups

P value less than 0.05 was considered statistically significant

Table 5 Comparison between the three groups as regard the vital data

	Group A (*n*=20)	Group B (*n*=20)	Group C (*n*=20)	A vs B	A vs C	B vs C	*p*-value (ANOVA)
				Post hoc Tukey's test			
Mean BP immediately after surgery (mmHg)	76.55 ± 3.76	81.55± 2.44	82.25± 3.46	<0.001*	<0.001	0.77	<0.001
Mean BP after 1 hr (mmHg)	79±2.99	81.7 ± 2.27	82.15± 2.92	0.008	0.002	0.86	0.001
Mean BP after 6 hr (mmHg)	79.3±2.83	81.95±2.19	82.6±3.03	0.008	<0.001	0.73	<0.001
Mean BP after 12 hrs (mmHg)	79.05±2.28	83.6 ± 2.83	83.5±2.5	<0.001	<0.001	0.9	<0.001
Mean BP after 24 hrs (mmHg)	79.75 ±1.83	83.9± 1.8	84.1±1.86	<0.001	<0.001	0.94	<0.001
Mean BP after 36 hrs (mmHg)	80.65 ± 2.34	84.85±1.95	84.45±1.8	<0.001	<0.001	0.8	<0.001
Mean BP after 48 hrs (mmHg)	82±1.75	85.15±2.16	84.65±2.1	<0.001	<0.001	0.71	<0.001

Data are presented as mean and standard deviation

Post-operative vital data events were compared between the three groups, mean blood pressure was lower in the epidural group (group A) compared to the femoral and adductor groups (group B and C). Although, there was no significant difference between the femoral & adductor groups

BP Blood pressure

P value less than 0.05 was considered statistically significant. pairwise comparison within the ANOVA data was done using post hoc Tukey's test

Table 6 Postoperative nausea and vomiting (PONV) and itching

		Group A		Group B		Group C		*P*-value
Nausea and vomiting	Yes	9	45%	3	15%	2	10%	0.018
	No	11	55%	17	85%	18	90%	
Itching	Yes	7	35%	2	10%	1	5%	0.024
	No	11	65%	18	90%	19	95%	

Data are presented as mean and standard deviation

The incidence of postoperative nausea & vomiting and itching was greater in the epidural group (group A) than in the femoral and adductor groups

P value less than 0.05 was considered statistically significant

there was no statistically significant difference between the ACB and FNB groups as regard overall VAS score, total opioid consumption, incidence of complications or interrupted sleep during all observation times. This finding matched our findings (Tan et al. 2018).

On the other hand, in A randomized controlled study performed by *Vishwanatha and Kalappa*on 60 patients, there was no significant difference in mean VAS in both Continuous femoral nerve blockade group & epidural analgesia groups postoperatively. The difference in the findings could be caused by different concentrations of local anesthetic in epidural continuous infusion (0.0625%) (Vishwanatha and Kalappa 2017).

The findings of our study disagreed with the randomized blinded study done on 42 patients by *Wiesmann et* al that compared between Continuous adductor canal block and continuous femoral nerve block for mobilisation capability and pain management. The pain scores in the ACB group were significantly lower than the CFNB group at postoperative day one. However, Overall patient satisfaction was comparable in the two groups which may be explainable by use of

the intravenous analgesia including non-opioids as well as opioids after the surgery or as a rescue analgesia for intense pain after discharge to the ward (Wiesmann et al. 2016).

In contrast to our study, a retrospective cohort study was performed on 80 patients by *Alsheikh et al*, the mean pain score was significantly greater among the epidural group than the ACB group. This may be attributed to the lower concentration of local anaesthetic drug used in the epidural group (ropivacaine 0.1% in combination with fentanyl) while in the ACB group, ropivacaine 0.2% was used (Alsheikh 2020).

As regard the incidences of adverse effects, Patients in the epidural group experienced more side effects than the other two groups. 9 patients in the epidural group experienced PONV in comparison with 2 and 3 patients in the femoral and adductor groups respectively. Also, itching was greater in epidural group (7 patients) than the femoral and adductor groups (2 and 1 respectively). Mean of Mean arterial pressure (MAP) in the epidural group was statistically significantly lesser in comparison with other groups but not of clinical significance.

Postoperative urinary retention could not be assessed as some patients were catheterized, so it was excluded from the results of this study.

Conclusions

In our study, we concluded that continuous epidural analgesia provides superior analgesia following total knee replacement than continuous femoral nerve block and continuous adductor canal block, with relatively more adverse effects such as pruritus and PONV.

Both CFNB & continuous ADB are good alternatives with fewer systemic side effects.

Abbreviations

ACB	Adductor canal block
ASA	American Society of Anaesthesiologists Physical Status
BMI	Body mass index
CFNB	Continuous femoral nerve block
ECG	Electrocardiogram
FA	Femoral artery
FN	Femoral Nerve
IV	Intra venously
LA	Local anesthetic
LOR	Loss of resistance
MAP	Mean arterial pressure
PACU	Post Anesthesia Care Unit
PCA	Patient-controlled analgesia
PONV	Postoperative nausea and vomiting
SD	Standard deviation
SN	Saphenous Nerve
SpO2	Peripheral oxygen saturation
SPSS	Statistical Package for Social Science
TKA	Total knee arthroplasty
TKR	Total knee replacement
VAS	Visual analogue scale

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Not Applicable.

Authors' contributions

RN designed the study, revised the literature, performed the analysis, followed up the patients, measured and calculated VAS scores, and wrote the manuscript. HA designed the study, performed the analysis, and wrote and critically revised the manuscript. WT revised the literature, performed the analysis, and critically reviewed the manuscript. AE revised the literature, followed up the patients, measured and calculated the blood loss, collected the data, performed the analysis, and critically reviewed the manuscript. AS followed up the patients, measured and calculated the VAS scores, collected the data, performed the analysis. All authors approved the final version of the manuscript.

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None.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Between February 2022 to July 2022, this prospective randomized controlled study was performed at Ain Shams University hospitals. Approval number (FAMSU M D 275/ 2020) was given by the Research Ethical committee at the faculty of medicine, Ain Shams University and it was registered at Clinical Trials.gov with identification code: NCT05249478.Written informed consent had been taken from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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