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Comparative study between continuous adductor canal block and intravenous morphine for postoperative analgesia in total knee arthroplasty

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Abstract

Background: Postoperative pain after total knee arthroplasty (TKA) is known to range from moderate (30% of patients) to severe (60% of patients). Inadequate management for postoperative pain may induce various immobility-related complications, muscle weakness, and chronic pain. Therefore, post-TKA analgesia is crucial, not only for patients' satisfaction, but for improving surgical outcomes and reducing complications. The present study aims to compare the effect of ultrasound-guided adductor canal block ACB (saphenous nerve block) versus incremental dose of intravenous morphine after total knee arthroplasty surgery.

Results: The results of this study revealed no difference between group A and group B as regards postoperative quadriceps muscle strength; maximal knee flexion, total distance ambulated, and postoperative vital data (heart rate per minute and respiratory rate per minute). However, group A showed better postoperative pain control, lower doses of intravenous morphine consumption and lower incidence of nausea and vomiting.

Conclusion: Continuous adductor canal block (saphenous nerve block) is superior to intravenous morphine in decreasing postoperative pain and decreasing total morphine consumption and adverse effects as nausea and vomiting, but both are equivalent in preserving quadriceps muscle power.

Keywords: US-guided continuous ACB, Total knee arthroplasty, IV morphine consumption

Background

Total knee arthroplasty (TKA) is a successful intervention for patients with painful degenerative diseases affecting the knee joint. The management of pain after TKA has always been a key focus in the clinical treatment of patients undergoing this procedure (Hanson et al. 2014).

Postoperative pain leads to decreased ability to mobilize the knee, prolonged hospitalization, and increased complications. Despite comprehensive multimodal analgesic regimens, this problem has not been successfully addressed (Charous et al. 2011).

For post-TKA pain, continuous adductor canal block (ACB) compared with intravenous patient-controlled analgesia alone, addition of ACB to an analgesic regimen provides superior pain control, reduces the incidence of postoperative complications, and shortens the time to functional recovery (Kapoor et al. 2012).

Peripheral nerve blocks are increasingly preferred to relieve postoperative pain and to reduce opioid consumption and opioid-related adverse effects in patients undergoing total knee arthroplasty (Bauer et al. 2012).

Continuous adductor canal block affects not only the two largest sensory contributors from the femoral nerve

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to the knee, namely, the saphenous nerve and the branch to the vastus medialis, but also the articular branches of the obturator nerve. However, the block is distal to most of the efferent branches to the quadriceps muscle and therefore largely preserves the strength of this muscle (Dixit et al. 2014).

Methods

This randomized prospective comparative study was carried out in a surgery hospital after approval of the Research Ethics Committee (REC) and obtaining a written informed consent from the patient. Total (54) patients above the age of twenty who had unilateral TKA under general anesthesia between (September) 2018 and (September) 2019 were included (Fig. 1).

The study included patients from both genders (ASA physical status I to II) who were scheduled for unilateral TKA under general anesthesia and had average body weight (BMI < 35).

Patients who refused to participate in the study, had allergy from morphine or local anesthetics (Bupivacaine), had coagulopathy, were chronic opioid user (> 1 month of 60 mg morphine oral equivalents daily), had chronic hepatic or renal disease, had cancer or received chemotherapy or radiotherapy, and with ages below 20 years were excluded from the study.

Patients were randomly divided into 2 groups using closed envelope method, group A for ACB with continuous infusion of bupivacaine and group B for incremental doses of intravenous morphine after TKA.

Sample size

Using pass program setting alpha error at 5% and power at 80%. Result from previous study (Jenstrup et al. 2012) showed that the mean morphine consumption and continuous ACB was 40 ± 21 versus 36 ± 26 in control group. Based on this, the needed sample is 27 cases per group (54 total) (Jenstrup et al. 2012).

The medical history from all patients was taken with meticulous examination (general and orthopedic), and full pre-operative investigations (complete blood count, partial thromboplastin time, prothrombin time and concentration, liver and kidney function tests) were done.

All patients were kept fasting for 8 h preoperative. In pre-induction room, an IV cannula G20 was inserted, and monitors were attached (pulse oximetry, electrocardiogram, and non-invasive arterial blood pressure). All patients received 2 mg of midazolam; then, induction was started by general anesthesia with 2 mcg/kg of intravenous fentanyl then intravenous anesthetic (propofol 1–2 mg/kg). Muscle relaxant was used (atracurium by intubating dose: 0.4–0.5 mg/kg and 0.08–0.1 mg/kg as maintenance of neuromuscular block to be repeated every 15 min), and maintenance of anesthesia was done by inhalational anesthetics (isoflurane 1.2%).

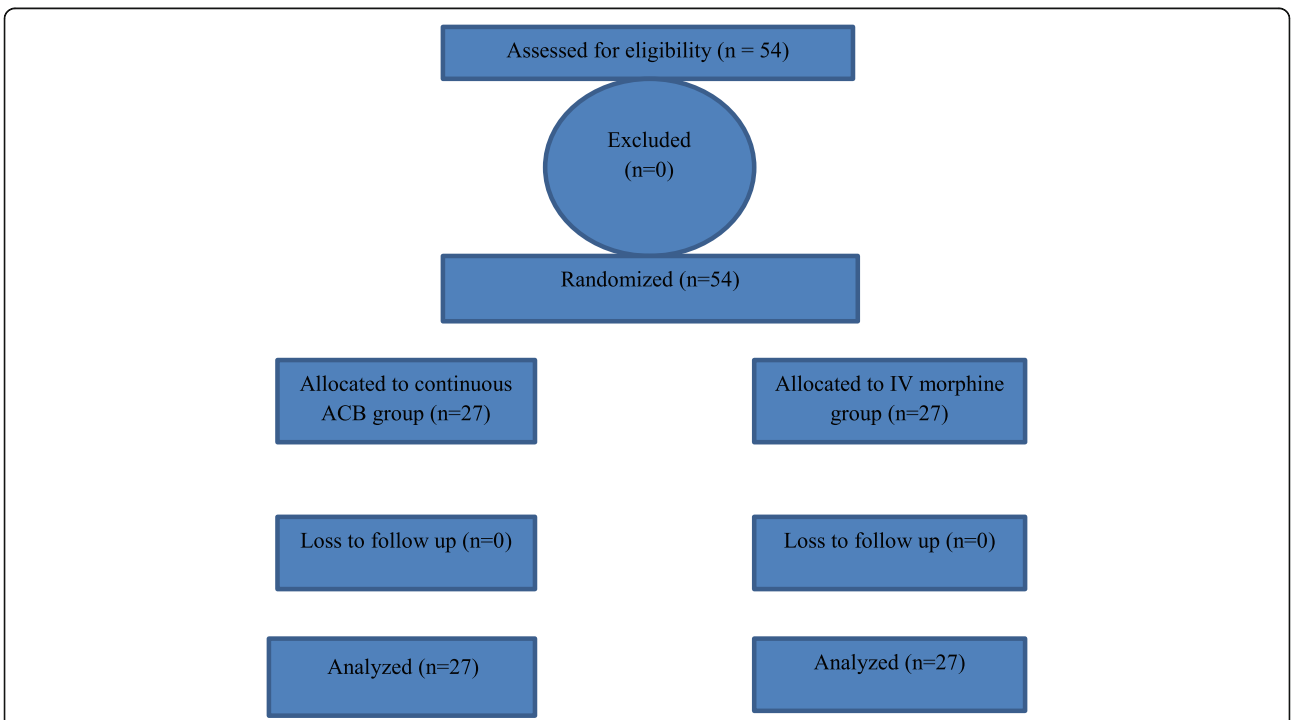

Fig. 1 Patient flowchart of comparative study between continuous adductor canal block and intravenous morphine for postoperative analgesia in total knee arthroplasty

In the operating room, surgical technique and prosthesis selection were left to each individual surgeon. In group A, the catheter was placed immediately after surgery. A high-frequency linear array ultrasound transducer was used to identify the adductor canal. The transducer was placed at the mid-thigh, half the distance between the inguinal crease and the patella. Next, the superficial femoral artery was identified dorsal/lateral to the sartorius muscle in short-axis. At this level, the hyperechoic structure located lateral/anterior to the artery was identified as the target catheter site at the adductor canal.

A 17-gauge Tuohy needle was placed lateral to the superficial femoral artery and within the adductor canal in which we used an in-plane ultrasound technique. A flexible 19-gauge open-tip epidural-type catheter was advanced 1 to 2 cm into the adductor canal. The needle was removed, and the continuous catheter was placed and secured with surgical glue and covered in a clear occlusive dressing. The catheter had been attached to a portable infusion pump.

Group A had received a continuous infusion of 0.25% bupivacaine at 8 mL/h with a portable infusion pump before emergence. Patient received rescue analgesia in the form of IV morphine (0.05 mg per kg) when pain score is above 3 in NRS.

Group B had received 5 mg morphine IV after emergence, and the rest of the 48 h, they had received incremental dose of intravenous morphine (dose was 0.05 mg per kg) according to pain score when it was above 3 in NRS every 6 h (time interval at which pain was assessed).

The primary outcome of our study during the first 48 h was cumulative opioid (morphine) consumption.

The secondary outcomes were pain assessment on the operative limb documented at 6, 12, 18, 24, 30, 36, 42, and 48 h postoperatively at rest by using Numerical Rating Scale Score (NRS) (Hawker et al. 2011), quadriceps strength of each patient which was evaluated by Bromage scale score criteria (Craig and Carli 2018), maximum knee flexion, distance ambulated, incidence of nausea, vomiting and postoperative heart rate per minute, and respiratory rate per minute which were assessed every 2 h for 48 h.

Statistical analysis

IBM SPSS statistics (V. 26.0, IBM Corp., USA, 2019) was used for data analysis. Data were expressed as mean ± SD for quantitative parametric measures in addition to both number and percentage for categorized data.

The following tests were done:

1. Comparison between two independent mean groups for parametric data using Student's *t* test.
2. Chi-square test to study the association between each 2 variables or comparison between 2 independent groups as regards the categorized data.
3. The probability of error at 0.05 was considered significant, while at 0.01 and 0.001 are highly significant.

Results

Table 1 shows no statistically significant difference between groups according to demographic data.

Table 2 shows highly significant difference between the two groups as regards pain after 6, 12, 18, 24, 30, 36, 42, and 48 h from end of surgery as $p < 0.001$.

Table 3 shows highly significant difference between the two groups as regards morphine consumption during the 48 h from operation as $p < 0.001$.

There was no significant difference between the two groups as regards Bromage scale score after day one and day two after end of surgery as $p > 0.05$ (Table 4).

There was no significant difference between the two groups as regards maximal knee flexion after day one and day two after end of surgery as $p > 0.05$ (Table 5).

There was no significant difference between the two groups as regards distance ambulated during the 48 h from operation as $p > 0.05$ (Table 6).

There was highly significant difference between the two groups as regards nausea during the 48 h after the end of surgery as $p < 0.05$ (Table 7).

There was highly significant difference between the two groups as regards vomiting during the 48 h after the end of surgery as $p < 0.05$ (Table 8).

There was no significant difference between the two groups as regards postoperative heart rate per minute and respiratory rate per minute after day one and day two after end of surgery as $p > 0.05$ (Table 9).

Discussion

This is randomized prospective comparative study which was carried out on 54 patients who had unilateral TKA under general anesthesia. They were randomly divided into two groups, 27 patients in group A who had continuous ACB and 27 patients in group B who had

Table 1 Comparison between the two groups regarding patient characteristics

	Group A (*n* = 27)	Group B (*n* = 27)	*P*
Age (years), mean ± SD	43.63 ± 11.956	44.52 ± 10.177	0.77
Gender			
Male	21 (77.8%)	20 (74.1%)	0.750
Female	6 (22.2%)	7 (25.9%)	
BMI, mean ± SD	29.9 ± 3.14	30.2 ± 4.62	0.332

Pearson Chi-square
p value > 0.05 NS; *p* value < 0.05 S; *p* value < 0.001 HS
HS highly significant, *n* numbers, *SD* standard deviation

Table 2 Comparison between the two groups regarding pain at 6, 12, 18, 24, 30, 36, 42, and 48 h after surgery

Pain	Group A	Group B	*t*	*P*
6 h, mean ± SD	3.37 ± 0.84	6.63 ± 0.69	15.613	0.001
12 h, mean ± SD	2.41 ± 0.50	4.85 ± 0.53	17.355	0.001
18 h, mean ± SD	1.41 ± 0.50	3.85 ± 0.53	17.355	0.001
24 h, mean ± SD	1.37 ± 0.49	2.78 ± 0.42	11.262	0.001
30 h, mean ± SD	1.22 ± 0.42	3.30 ± 0.47	17.126	0.001
36 h, mean ± SD	1.11 ± 0.32	2.63 ± 0.49	13.439	0.001
42 h, mean ± SD	1.11 ± 0.32	2.56 ± 0.51	12.527	0.001
48 h, mean ± SD	1.19 ± 0.40	2.44 ± 0.51	10.18	0.001

t independent sample *t* test; Pearson Chi-square
p value > 0.05 NS; *p* value < 0.05 S; *p* value < 0.001 HS
HS highly significant, *SD* standard deviation, *sig.* significance

intravenous morphine only. We found no difference between group A and group B as regards postoperative quadriceps muscle strength: maximal knee flexion and total distance ambulated. However, group A showed better postoperative pain control, lower doses of intravenous morphine consumption, and lower incidence of nausea and vomiting.

Also, in a randomized, double-blind trial on 80 patients, the findings in this study agreed with the study of Hanson et al. (2014) on continuous ultrasound-guided adductor canal block for total knee arthroplasty. The continuous adductor canal block for total knee arthroplasty reduces opioid consumption in the first 48 h after surgery. As regards pain during the first 48 h after surgery, the peak median pain scores showed statistically significant reductions for the block group on postoperative days 1 and 2. Also, regarding quadriceps strength, there was no difference in strength between groups on postoperative day 1, and there was no difference between the groups in knee flexion (Hanson et al. 2014).

However, quadriceps strength was significantly greater in the block group on postoperative day 2 compared with that of placebo, and the block group showed a statistically significant improvement in maximum distance ambulated compared with that of the control group on postoperative day 2 as which was against our study.

Table 3 Comparison between the two groups regarding morphine consumption during the 48 h from operation

	Group A	Group B	*t*	*P*
Morphine consumption, mean ± SD	5.78 ± 1.22	12.74 ± 1.95	15.713	0.001

t independent sample *t* test; Pearson Chi-square
p value > 0.05 NS; *p* value < 0.05 S; *p* value < 0.001 HS
HS highly significant, *sig.* significance, *SD* standard deviation

Table 4 Comparison between the two groups regarding Bromage scale score at day one and day two from operation

Bromage scale score	Group A	Group B	*t*	*P*
Day one, mean ± SD	1.19 ± 0.40	1.00 ± 0.39	1.727	0.09
Day two, mean ± SD	0.93 ± 0.39	1.00 ± 0.56	0.57	0.571

t independent sample *t* test; Pearson Chi-square
p value > 0.05 NS; *p* value < 0.05 S; *p* value < 0.001 HS
sig. significance, *NS* non-significant, *SD* standard deviation

On the other hand, nausea and vomiting showed no differences between the two groups of Hanson et al. (2014). This difference from our study may be due to usage of intravenous patient-controlled analgesia (PCA) for day 1, and then, it was replaced with oral morphine according to VAS (Hanson et al. 2014).

In the study of Kim et al. (2019), forty-four patients who underwent TKA were randomly divided into continuous ACB group (Group CACB) or IV-PCA with a single-shot ACB group (Group IVACB). Before the operation, ultrasound-guided ACB with 0.5% ropivacaine 20 cc was provided to all patients. Before skin incision, the infusion system (0.2% ropivacaine through an adductor canal catheter in group CACB versus intravenous fentanyl in group IVACB) was connected. Our results matched with their study in pain NRS which was significantly different between the two groups within the 48 h after surgery, the morphine doses of total rescue analgesics were significantly different between the two groups, and continuous ACB had minimized the use of additional antiemetic. Also, quadriceps muscle strengths were not significantly different. It maximally decreased 24 h after surgery, and then gradually recovered over 4 days postoperatively in both groups. No significant differences between the groups were recorded for quadriceps muscle strength at any time point. In their study, quadriceps muscle strength diminished even after the analgesic effect of the single-shot ACB, suggesting that other factors were related to motor weakness other than the motor block by the ACB (Kim et al. 2019).

Our results were also supported by the study of Abdallah et al. (2016) on 100 patients comparing the effect of adductor canal block versus femoral nerve block by

Table 5 Comparison between the two groups regarding maximal knee flexion at day one and day two from operation

Maximal knee flexion	Group A	Group B	*t*	*P*
Day one, mean ± SD	34.89 ± 4.79	34.07 ± 4.46	0.647	0.521
Day two, mean ± SD	50.11 ± 5.48	48.33 ± 5.37	1.204	0.234

t independent sample *t* test; Pearson Chi-square
p value > 0.05 NS; *p* value < 0.05 S; *p* value < 0.001 HS
sig. significance, *NS* non-significant, *SD* standard deviation

Table 6 Comparison between the two groups regarding distance ambulated during the 48 h from operation

	Group A	Group B	*t*	*P*
Distance ambulated, mean ± SD	20.11 ± 4.51	21.37 ± 2.66	1.25	0.218

t independent sample *t* test; Pearson Chi-square
p value > 0.05 NS; *p* value < 0.05 S; *p* value < 0.001 HS
sig. significance, *NS* non-significant, *SD* standard deviation

Table 8 Comparison between the two groups regarding vomiting during the 48 h from operation

Vomiting	Group A (*n* = 27)	Group B (*n* = 27)	*P*
No, *n* (%)	26 (96.3%)	18 (66.7%)	0.005
Yes, *n* (%)	1 (3.7%)	9 (33.3%)	

t independent sample *t* test; Pearson Chi-square
p value > 0.05 NS; *p* value < 0.05 S; *p* value < 0.001 HS
HS highly significant, *sig.* significance, *n* numbers, *SD* standard deviation

using 20 ml ropivacaine 0.5% in both groups. They tested the analgesic efficacy using numerical pain scale score, and they found that adductor canal block is not inferior to femoral nerve block regarding pain scores in the first 24 h. Both of our studies agreed on low doses of morphine consumption in the first 24 h. They tested quadriceps muscle strength by using a dynamometer to measure maximal voluntary isometric contractions MVIC, and they found that adductor canal block group is superior to femoral nerve block in preserving quadriceps muscle strength which supported our study in sensory blockage of ACB rather than motor blockage (Abdallah et al. 2016).

Also, a randomized, placebo-controlled study of Hanson et al. (2017) on eighty patients investigated the opioid-sparing effect of a continuous 0.2% ropivacaine infusion at the adductor canal guided by ultrasound in patients undergoing unilateral knee arthroplasty or a sham catheter. All patients received a preoperative single-injection femoral nerve block with spinal anesthesia. Both studies showed that total mean morphine consumption over 48 h was less in the adductor canal block group compared with that of the sham group, and the peak median pain score showed statistically significant reduction in adductor group than sham group. Also, there was no difference in quadriceps strength between groups on postoperative day 1, but quadriceps strength was significantly greater in the block group on postoperative day 2 compared with that of sham group. On the other hand, the block group showed a statistically significant improvement in maximum distance ambulated compared with that of the sham group on postoperative day 2. Also, there were no differences found in the incidence of nausea or vomiting between the two groups which may be due to the transition from IV to oral morphine after day 1 from the operation which was against our study (Hanson et al. 2017).

Ardon et al. (2016) in their study on ninety patients had 45 patients with continuous ACB and 45 with continuous femoral block FB. On post-operative day 1, median anterior knee NRS at rest was equivalent in both the ACB and FB groups which supports our study; however, patients in the ACB group were more likely to have higher anterior knee pain scores with movement. Also, they supported our study in opioid consumption which was not significantly different between patients in continuous FB and patients who had received continuous ACB. Continuous adductor canal block appears to provide adequate analgesia when compared to continuous femoral blockade (Ardon et al. 2016).

The analgesic effects of the ACB versus FB is still of controversy which has been reported to be better than those of the FNB of Li et al. (2016), and similar with Mudumbai et al. (2016), or inferior as Memtsoudis et al. (2015) found in their qualitative comparison; a significant proportion of patients reported the leg receiving ACB to be more painful than that receiving FNB at 24 h.

The reasons for the decrease in muscle strength may be multiple. One probable factor is a motor blockade by the proximal spread, volume, and concentration of local anesthetics, although several previous studies report that the ACB could reduce quadriceps muscle strength (Burckett-St Laurant et al. 2016).

On the other hand, most of the studies convincingly report that ACB preserves quadriceps muscle strength better than other peripheral nerve blocks used for postoperative analgesia after TKA which was matched with our study (Mudumbai et al. 2016).

Table 7 Comparison between the two groups regarding nausea during the 48 h from operation

Nausea	Group A (*n* = 27)	Group B (*n* = 27)	*P*
No, *n* (%)	25 (92.6%)	18 (66.7%)	0.018
Yes, *n* (%)	2 (7.4%)	9 (33.3%)	

Pearson Chi-square
p value > 0.05 NS; *p* value < 0.05 S; *p* value < 0.001 HS
sig. significance, *NS* non-significant, *n* numbers, *SD* standard deviation

Table 9 Comparison between the two groups regarding postoperative heart rate per minute and respiratory rate per minute every 2 h for 48 h after end of surgery

	Group A	Group B	*t*	*P*
Heart rate per minute, mean ± SD	82.42 ± 3.239	81.5 ± 4.493	0.87	0.388
Respiratory rate per minute, mean ± SD	14.69 ± 1.05	14.46 ± 0.922	0.845	0.402

t independent sample *t* test; Pearson Chi-square
p value > 0.05 NS; *p* value < 0.05 S; *p* value < 0.001 HS
HS highly significant, *SD* standard deviation, *sig* significance

Conclusion

Continuous adductor canal block (saphenous nerve block) is superior to intravenous morphine in decreasing postoperative pain and decreasing total morphine consumption and adverse effects as nausea and vomiting, but both are equivalent in preserving quadriceps muscle power.

Abbreviations

ACB: Adductor canal block; ASA: American Society of Anesthesia; BMI: Body mass index; CACB: Continuous adductor canal block; FNB: Femoral nerve block; IV: Intravenous; IV-PCA: Intravenous patient-controlled analgesia; MKF: Maximal knee flexion; MVIC: Maximal voluntary isometric contraction; NRS: Numerical rating scale; TKA: Total knee arthroplasty; US: Ultrasonography; VAS: Visual analog scale

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Authors' contributions

HA designed the study, revised literature, performed the analysis, followed the patients, performed the adductor canal block by using ultrasound, measured vital data, assessed Bromage scale score, assessed postoperative morphine consumption and pain numerical rating scale score, and wrote the manuscript. BN designed the study, performed the analysis, and wrote and critically revised the manuscript. HL revised the literature, performed the analysis, and critically reviewed the manuscript. RG and DH revised the literature, followed the patients, collected the data, performed the analysis, and critically reviewed the manuscript. All authors approved the final version of the manuscript.

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Availability of data and materials

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

Ethics approval and consent to participate

Approval of Research Ethical Committee of Faculty of Medicine, Ain Shams University was obtained (code number: FMASU MD 46/2018), and informed written consent was obtained from patients.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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