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ORIGINAL RESEARCH ORTHOPEDIC ANESTHESIA

Adductor canal block as a part of multimodal analgesia protocol for total knee arthroplasty

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Abstract

Background & Objective: Effective analgesia is necessary for early postoperative recovery following total knee arthroplasty (TKA). Various combinations of pain relief modalities have been used for postoperative pain in TKA. Adductor canal block (ACB) has been suggested to have a role in this scenario. We evaluated the effectiveness of ACB following spinal anesthesia (SA) in terms of postoperative pain relief, early ambulation and patient satisfaction.

Methodology: A total of 72 patients were enrolled in the study. Out of these 36 patients (Group A) were randomized to receive ACB in addition to SA, while 36 patients (Group B) received only SA. Postoperative numerical rating scale (NRS) score, and morphine consumption were noted at shifting to PACU, at 6, 12, 18 and 24 h postoperatively as a primary outcome measure. As a secondary outcome measures, quadriceps muscle power, time to ambulation and patient satisfaction were evaluated.

Results: A statistically significant drop in NRS was noted in Group A, at 6, 12, 18, and 24 h after surgery, but not in the postoperative care unit (P = 0.75), and a decrease in the total morphine use among patients who underwent an ACB. A significant change was noted in ambulation and patient satisfaction in the Group A, with no significant change in quadriceps muscular power among both groups.

Conclusion: ACB as a part of pain management strategy is successful in reducing postoperative pain, morphine consumption, enabling early ambulation, and elevating patient satisfaction.

Key words: Adductor canal block; Spinal Anesthesia; Total knee arthroplasty

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1. Introduction

Healthcare institutions strive to improve fast-track discharge programs to reduce hospital stay and cost, as well as to improve the outcomes and patient satisfaction after total knee arthroplasty (TKA). There are many protocols which include surgical techniques improvement, systemic analgesics, periarticular injection (PAI), femoral nerve block (FNB) and Adductor canal block (ACB) for postoperative pain

control. Multiple studies showed that ACB can play a role in decreasing postoperative pain in addition to accelerating ambulation postoperatively.[1]

Femoral nerve block was commonly used after TKA but it may cause quadriceps weakness and delayed ambulation causing increased risk of falls.[2]

ACB has been used instead of femoral nerve block because it showed less effect on quadriceps strength. The vastus medialis nerve, saphenous nerve, and posterior branch of the obturator nerve are all sensory pathways that are distally blocked at the mid-thigh level, while the quadriceps remain unaffected.[3] ACB produces analgesia as good as femoral nerve block but with earlier ambulation so, ACB was included in a total joint protocol.[4]

We evaluated the effectiveness of ACB a as postoperative analgesia following spinal anesthesia for TKA in terms of postoperative pain relief and morphine consumption as a primary outcome; and early ambulation and patient satisfaction as secondary outcome measures.

2. Methodology

This study was conducted at Ain Shams University Hospitals and is a randomized, prospective, and comparative trial. After receiving departmental ethical committee approval and the patients' written informed consents, 72 patients between the ages of 50 and 70 y, of both sexes, with ASA physical status II and III, underwent unilateral total knee arthroplasty under spinal anesthesia. Using the closed envelope method, they were randomly divided into two groups of 36 patients each: one group received an adductor canal block (Group A), and the other group did not (Group B).

Patient refusal, revision total knee arthroplasty, previous knee surgery, ASA class III or IV, any contraindication to spinal anesthesia, allergy to morphine or local anesthetic, and coagulopathy were the exclusion criteria.

Pre-operative assessment included a complete blood film, partial thromboplastin time, prothrombin time, INR (international normalized ratio), serum creatinine, and liver function tests. Orthopedic and general examinations were performed on all patients. The Numerical Rating Scale (NRS) was explained to all patients before surgery.

All TKAs were done by a trained surgeon under spinal anesthesia consisting of 3.5 mL hyperbaric bupivacaine 0.5% and 25 µg fentanyl via 25G spinal needle at L4–L5 intervertebral space. The patients were fasted for 8 h preoperatively. An IV cannula G18 was put in the pre-induction room before the procedure, along with basic monitors for pulse oximetry, ECG, and non-invasive arterial blood pressure. All subjects received an infusion of paracetamol 500 mg and ketorolac 30 mg.

The L4−L5 interspace was located after the patient was placed in seated position, sterile drape was applied, and local anesthetic was administered into the skin at the intended site of insertion. A midline approach was used while the spinal needle advanced in a cephalad angle of 10° to 15°. The local anesthetic was slowly administered and the needle was withdrawn. The patient was placed in a supine position and the sensory level was tested while monitoring vital signs. Following the surgical procedure, ACB was initiated with 20 mL of 0.5% bupivacaine through 22 G short beveled needle was injected in the Group A patients using an ultrasound device with a high frequency linear transducer 8–14 MHz (Sonosite M-Turbo®). The thigh was positioned in abduction and external rotation allowing exposure to the medial thigh. After cleaning the skin, the transducer was positioned anteriorly, at the point where the middle and distal thirds of the thigh meet. At the mid-thigh level, an ACB was carried out. The femoral artery was approached after the needle was put in-plane in a lateral-to-medial orientation. A 20 ml solution was injected after the needle tip was carefully aspirated and observed anterior to the artery.

Both patient groups received paracetamol 500 mg IV every 6 h , ketorolac either 15 mg IV every 6 h (maximum daily dose to be 120 mg), dose reduction by 50% if the subject was over 65 y old or weighed less than 50 kg, and as a rescue medication; if NRS ≥ 7, morphine 3 mg was infused over 4-5 min.

Morphine consumption was measured in the PACU, at 6 h, 12 h, 18 h and 24 h postoperatively. Total morphine consumption was measured in 24 h. NRS score was evaluated for pain at each time point by the nursing staff.

Quadriceps muscle strength was assessed by requesting the patient to extend their knee while the examiner fixed their thigh at the following intervals: preoperatively, at 6, 12, 18 and 24 h after surgery. The results were graded on a scale of 0 to 5; Grade 0 = inability to contract the muscle, Grade 1 = minimal contraction, Grade 2 = able to perform full range of motion of the quadriceps, but only on a horizontal plane and not against gravity, Grade 3 = able to hold the leg up against gravity, without additional pressure, Grade 4 = able to hold the leg up while a moderate pressure was applied and Grade 5 = normal, full movement.

The onset of ambulance was evaluated after the recovery of motor power in the contralateral limb and leg raising in the ipsilateral limb.

A linear numerical scale was used to calculate the satisfaction score, with 0 representing total discontent and 10 representing total satisfaction. Subjects gave a

Table 1: Comparison of groupings based on demographic information

Demographic data		Group A (n = 36)	Group B (n = 36)	T/x2	p-value
Age (y)		60.6 ± 6.1	60.78 ± 6.2	0.1t	0.9
ASA	II III	26(72.2%) 10(27.8%)	27(75%) 9(25%)	0.07 x2	0.79
Sex (Males)		19(52.8%)	19 (52.8%)	0.0x2	1

Table 2: Comparison between groups in reference to NRS

NRS	Group A (n = 36)			Group B (n = 36)			Z	P-value
	Range	Median	IQR	Range	Median	IQR		
PACU	0-2	1	0-2	0-2	1	0-2	0.32	0.75
6h	0-3	1	1-2	4-8	6	5-7	*7.4	**< 0.001**
12 h	2-4	2.5	2-3	2-7	6	5-7	*6.8	**< 0.001**
18h	2-7	4	3.5-5	5-8	7	5-7	*5.7	**< 0.001**
24 h	3-7	5.5	4-7	5-8	7	7-7	*4.2	**< 0.001**

** Value of significant statistical difference*

Table 3: Comparison between groups as regard morphine consumption

Morphine consumption (mg)	Group A (n = 36)			Group B (n = 36)			Z	P-value
	Range	Median	IQR	Range	Median	IQR		
Total 24h	0-6	0	0-3	3-12	6	3-9	*6.3	**< 0.001**
PACU	0-0	0	0-0	0-0	0	0-0	0	**1**
6h	0-0	0	0-0	0-3	0	0-3	*4	**< 0.001**
12h	0-0	0	0-0	0-3	0	0-3	*4.3	**< 0.001**
18h	0-3	0	0-0	0-3	3	0-3	*4.4	**< 0.001**
24h	0-3	0	0-3	0-3	3	3-3	*3.2	**0.001**

***** Value of significant statistical difference*

verbal assessment of the quality of analgesia in the first 24 h after the procedure from 0−10.

Statistical analysis

Statistical Package for Social Science (SPSS) version 22.0 was used. Quantitative information was presented as mean, standard deviation (SD), or as median and interquartile range (IQR). Frequency and percentage were used to express qualitative data. In order to compare proportions between two qualitative parameters, the Chi-square (X2) test of significance was used, and the Mann-Whitney U test was used for two-group comparisons in non-parametric data. The allowable margin of error was set at 5%, while the confidence interval was set at 95%. Therefore, in terms of probability (P-value), a $P \leq 0.05$ was regarded as significant, a $P \geq 0.001$ as extremely significant, and a $P > 0.05$ as non-significant. According to Jenstrup et al., the expected mean morphine consumption 24 h after surgery in the study group was = 40 ± 21 mg, while it was 56 ± 26 mg in the control group. Using the PASS 11 program to calculate sample size, 36 patients in each group can be used to detect a difference between the two groups with an 80% power setting and a 5% error margin.

3. Results

There was no significant difference between the two groups regarding their demographic data in terms of age, sex, and ASA status ($P > 0.05$) (Table 1). NRS scores were significantly lower in the Group A, e.g., 1 (1-2), 2.5 (2-3), 4 (3.5-5), and 5.5 (4-7) respectively vs. 6 (5-7), 6 (5-7), 7 (5-7), and 7 (7-7) in the Group B at time intervals of 6 h, 12 h, 18 h and 24 h. There was no difference in NRS scores on arrival at PACU ($P = 0.75$) (Table 2). A statistical difference was noticed between two groups at all time intervals (6 h, 12 h, 18 h and 24 h) except at PACU as regard morphine consumption. Total 24 h morphine consumption between 2 groups was significantly less in Group A compared to Group B [0 (0-3) vs. 6 (3-9)] (Table 3).

Groups were comparable for quadriceps muscle power at specified intervals with no significant difference among both groups all over the first 24 h ($P > 0.05$) (Table 4).

Table 4: Comparative quadriceps muscle power in two groups

Time	Group A (n = 36)	Group B (n = 36)	Z	p-value
Pre-operative	3 (3-4)	3 (3-4)	0.76	0.44
6 h	2 (2-3)	2 (2-3)	0.17	0.86
12 h	4 (3-4)	4 (3-4)	0.24	0.81
18 h	4 (3-4)	4 (3-4)	0.24	0.81
24 h	4 (3-4)	4 (3-4)	0.24	0.81

Table 5: Comparison between groups as regard onset of ambulation and patient satisfaction

Parameter	Group A (n = 36)	Group B (n = 36)	T	p-value
Onset of ambulation (min)	568.3 ± 112.5	715 ± 120.3	5.3	**< 0.001**
Patient satisfaction	27 (75%)	7 (19.4%)	21.98	**< 0.001**

Groups were comparable for onset of ambulation with a statistically significant difference in favor of Group A (568.3 ± 112.5 min) (Table 5). Additionally, a significant difference was noted between the two groups regarding patient satisfaction 27 (75%) in the Group A vs. 7 (19.4%) in the Group B (Table 6).

4. Discussion

Severe postoperative pain following total knee arthroplasty (TKA) negatively impacts patients' functional recovery, postoperative rehabilitation, and other problems like infection, deep vein thrombosis etc.[5] So, it is necessary to ensure adequate analgesia after such procedure.[6] Postoperative pain after TKA may result in increased length of hospital stay (LOS), increased narcotic use, and delay of physical rehabilitation.[7] opiate-based pain remedies have been useful in decreasing pain, but it may cause perioperative complications such as postoperative ileus, hypotension and addiction.[8] ACB is associated with less adverse effects.[9]

This randomized study was performed to test the effectiveness of adductor canal block following a total knee arthroplasty in terms of postoperative pain scores using NRS score, measured at specific intervals postoperatively. Total morphine consumption, as a rescue analgesic, was calculated and quadriceps muscle strength postoperatively was clinically tested at same time intervals mentioned before. Start of ambulation and patient satisfaction were noted on a scale from 1 to 10 and recorded. Comparison between the two groups as regard NRS, showed significant differences at 6 h, 12 h, 18 h and 24 h time intervals, but at PACU no significant difference was recorded, showing more pain control in the Group A. These findings were similar to earlier studies which showed that adding an ACB to a multimodal pain control after TKA can be effective in decreasing postoperative pain in the first 24 h after surgery in addition to decrease opiate usage postoperatively.[10] Hebl et al., stated that a multimodal analgesic protocol which contains peripheral nerve blocks is associated with more control of postoperative pain.[11] According to Blanco et al., ACB is linked to sensory block for 18 to 22 h.[8] These results are consistent to our study, which indicated that after 12 h following surgery, the Group A used less morphine and experienced less postoperative pain than the Group B.

Jenstrup et al., described decreased discomfort and improved mobility in patients who underwent total knee replacement and received an adductor canal block compared to those who received a placebo, which is consistent with our findings.[12]

Also, the findings in our study concluded that ACB does not affect quadriceps muscle strength resulting in early rehabilitation, ambulation and more patient satisfaction. The data were consistent with findings in another study performed by Kwofie et al., who used 15 ml of 3% chloroprocaine comparing ACB to femoral nerve block (FNB) and observed quadriceps motor sparing resulting in better balance with ACB.[13]

Coinciding with our findings, a previous study showed that ACB was the best modality as regards the functional outcomes, as postoperative analgesia is crucial for faster recovery after TKA, and peripheral nerve blocks have a great role in achieving such outcomes.[14,15] peripheral nerve blocks do not affect respiratory function and hemodynamics dramatically, so their usage as modalities of analgesia, including FNB and ACB is very common.[16,17]

Kenneth A. demonstrated that adductor canal block spares quadriceps muscle power unlike in FNB. And Jaeger et al., showed preserved quadriceps power when ACB was used, unlike FNB which caused 8% reduction from the baseline. These data coincided with the results of our study.[18]

ACB is preferable to FNB and improves postoperative physical recovery, according to a study by Patterson et al.[19] Kim et al. reported positive outcomes in terms of

analgesia and muscle strength using 15−30 ml of 0.5% bupivacaine + epinephrine 5 µg/ml.[20] Sayed El-Ahl., demonstrated that quadriceps power is preserved with reduced analgesia when compared to FNB by injecting 15 ml of 0.5% ropivacaine.[21] According to Jaeger et al., ACB is superior to FNB in terms of sparing quadriceps muscular power, with little to no difference in postoperative pain.[18] Jenstrup et al., observed a decrease in the amount of morphine consumed with an improvement in pain levels following the administration of 30 ml of 0.75% ropivacaine; however, a much higher concentration may weaken the quadriceps muscle due to the distribution of local anesthetic proximally.[22]

ACB spares muscle strength and accelerates rehabilitation; but, it results in partial analgesia after TKA.[23] Nerve blocks cannot produce complete analgesic effect after TKA, and a combination of different pain control modalities is crucial.[24] The vastus lateralis and intermedius, both of which originate from the posterior division of the femoral nerve proximal to the adductor canal and immediately distal to the inguinal ligament, are also responsible for the sensory innervation of the knee joint. As a result, ACB may be less effective than a combined femoral and obturator block in managing pain following knee surgery. Blocking all nerves travelling via the adductor canal requires intermittent boluses, which can be administered by a nurse or a pump that allows for relatively high bolus volumes.[25]

There is no one analgesic treatment that can sufficiently control postoperative pain after TKA, according to a prior meta-analysis. Multimodal analgesia is crucial for reducing postoperative complications, length of hospital stay, and enhancing functional recovery and ambulation following surgery.[26] The proximal spread of local anesthetics can create a motor block, which is one of many factors that can contribute to decreased muscle strength. Several studies indicated that using ACB decreased the strength of the quadriceps muscle.[27] But, a lot of studies concluded that the ACB spares quadriceps muscle power as compared to other nerve blocks mentioned for pain control after TKA and offers good results when used in combination of other analgesic modalities, coinciding with the results of our study.[28]

5. Limitations

ACB results in partial analgesia after total knee arthroplasty, and a combination of different pain control modalities is crucial to achieve effective analgesia and improve outcome.

6. Conclusion

When used in conjunction with other pain management techniques for primary total knee arthroplasty, adductor canal block helps to reduce the need for morphine during the first 24 h following surgery and improves the postoperative pain. Additionally, it has no negative effects on the quadriceps muscle, thus enabling early ambulation and patient satisfaction.

7. Future scope

Incorporation of adductor nerve block into standard clinical practice can improve the quality of care provided to the patients with knee problems who require total knee arthroplasty.

8. Ethics approval and consent to participate

This study was approved by the research ethics committee at the faculty of medicine, Ain Shams University (FMASU MD 224 / 2020 / 2021) and registered with Pan African Clinical Trial Registry, identifier: PACTR202201730674988.Written informed consent was obtained from all patients.

9. Data availability

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

10. Conflict of interests

The authors declare that there were no conflicts of interest. This research did not receive any specific grant from any source.

11. Authors' contribution

All authors have contributed intellectually to the manuscript and the manuscript has been read and approved by all the authors. All authors have read the manuscript and approve it.

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