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Indian Journal of Clinical Anaesthesia

Journal homepage: www.ijca.in

Original Research Article

Evaluation of postoperative analgesic efficacy of dexmedetomidine as adjuvant with ropivacaine in ultrasound guided adductor canal block in patients undergoing unilateral Total Knee Replacement

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ARTICLE INFO

Article history:

Received 07-01-2022

Accepted 09-01-2022

Available online 12-02-2022

Keywords:

Analgesia

Dexmedetomidine

Ropivacaine

Adductor canal block

Ultrasound

Total knee replacement

Regional anaesthesia

ABSTRACT

Background: The aim of anaesthesia in Total knee replacement (TKR) is to provide adequate analgesia and early ambulation. The recent success of adductor canal block in providing post-operative analgesia and achieving early ambulation has evoked interest in studying the effects of local anaesthetic agents and various adjuvants.

Materials and Methods: This study was a randomized three arm parallel group comparative study conducted in a tertiary care center in India on 135 patients undergoing unilateral total knee replacement under spinal anaesthesia. After completion of the surgery, the adductor canal block was performed with ultrasound guidance at mid-thigh level in all three groups. In group A, 20 ml 0.375% ropivacaine was only used but in group B and C Dexmedetomidine was added to ropivacaine (total volume of 20 ml; 0.375%) at a dose of 0.25 µg/kg and 0.50 µg/kg respectively. The primary outcome of the study was to compare duration of analgesia after the adductor canal block.

Results: Duration to rescue analgesia (in hours) was significantly longer [Group A: 15.71±4.87; Group B: 16.44±6.21; Group C: 19.78±5.57 (p=0.014)] and total opioid (24 hours tramadol needed in mg) consumption [Group A: 60.00±13.94; Group B: 52.22±18.80; Group C: 33.33±13.95 (p=0.033)] was significantly lower in Group C. NRS scores both at movement and rest were significantly lesser in Group C at 18 and 24 hours timepoints. Patient satisfaction was significantly higher in Group C with 46.67% patient reporting better than expected peri-operative experience (p=0.022).

Conclusion: The addition of dexmedetomidine, 0.5 µg/kg to 0.375% ropivacaine in adductor canal block results in longer duration of analgesia, less 24 hours opioid consumption, better motor strength and better patient satisfaction without any adverse effect after unilateral total knee replacement surgery.

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1. Introduction

Total knee replacement (TKR) is one of the commonly performed surgeries in modern orthopedics but is often associated with severe pain. The aim of anaesthesia in

such cases is to provide adequate analgesia so as to facilitate early ambulation. This aim is directed at decreased hospital stay and increased patient satisfaction. Multimodal analgesia with the use of central and peripheral nerve blocks, non-steroidal anti-inflammatory Drugs (NSAIDs), paracetamol, opioids, etc. is most suited for this surgery. Since ages combined spinal epidural anaesthesia remained

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the mainstay for TKR. However, epidurals for postoperative analgesia has its own grave complications such as catheter related issues and side effects of opioids. In addition, the use of systemic opioids and NSAIDs especially in elderly population is equally warranted. The recent success of adductor canal block in providing post-operative analgesia, along with the prospects of early ambulation has evoked interest in studying the effects of opioid sparing anaesthetics such as local anaesthetics and some safer adjuvants like dexmedetomidine.

With the advent of ultrasonography (USG), adductor canal block (ACB) can be administered with a high success rate.^{1,2} In recent years, ACB has been successfully used for postoperative pain control after knee surgery.^{1,3} Jenstrup et al. concluded that the adductor-canal-blockade significantly reduced morphine consumption and pain during 45 degrees flexion of the knee compared with placebo. Also, the adductor-canal-blockade significantly enhanced ambulation ability assessed by the Timed Up and Go (TUG) test.⁴

The present study was done to compare the duration of analgesia of adductor canal block using ropivacaine with and without dexmedetomidine after unilateral total knee replacement. Also, secondary aim of the study was to find out the optimal dose of dexmedetomidine as an adjuvant to ropivacaine.

2. Materials and Methods

This study was a randomized controlled three-arm parallel group trial conducted in New Delhi after approval by the institutional ethics committee and clinical trial registration (CTRI/2018/03/012763). Total 135 patients of either sex belonging to ASA grade I or II, aged 18 to 75 years undergoing elective unilateral total knee replacement surgery under spinal anaesthesia were included in this study. Patients with allergy to any of the study drugs, cardiac or renal disease, any neurological ailment, contraindication to spinal anaesthesia and pregnancy were excluded from the study.

Patients were divided into three different groups (n=45 each) using computer generated randomization table;

Group A: 20 ml solution of Ropivacaine (0.375%) was given in ACB.

Group B: 20 ml solution of Ropivacaine (0.375%) with 0.25mg/kg dexmedetomidine was given in ACB.

Group C: 20 ml solution of Ropivacaine (0.375%) with 0.50mg/kg dexmedetomidine was given in ACB.

The primary outcome of the study was to compare the duration of postoperative analgesia. The secondary outcomes were to compare 24-hour opioid consumption after surgery, success of early ambulation, level of patient satisfaction and any adverse effects following the study intervention.

For sample size calculation it was hypothesized that addition of Dexmedetomidine to Ropivacaine will increase

the duration of analgesia by 50%. Thus, the sample size was calculated as 45 in each group to attain minimum 90% power and to reduce the alpha error to 5% (to achieve 95% confidence level) using sample size calculation software MEDCALC™ (Ostend, Belgium).

Standard pre-anaesthetic evaluation and basic lab investigations were done a day prior to the surgery. The entire procedure was explained to the patient and written informed consent was obtained. Patients were shifted to the operation theatre (OT) on the day of surgery and all standard ASA monitors were attached. All the patients were given subarachnoid block with 2.5 ml 0.5% hyperbaric bupivacaine and through 25G Whitacre spinal needle via L3-L4 intervertebral space after local infiltration with 2% lignocaine.

General anaesthesia was administered in those patients who either had inadequate effect of subarachnoid block or where subarachnoid block was contraindicated. For analgesia in such cases Fentanyl 2 µg/kg IV was used. The same team of orthopedic surgeons performed all the surgeries.

After completion of the surgery, the adductor canal block (ACB) was performed by an experienced anaesthesiologist with help of a linear ultrasound probe (5–10 MHz; Mindray Z 6, Shenzhen Mindray Biomedical Electronics Ltd, China). An independent researcher generated the randomization code on the basis of a computer-generated randomization table using www.graphpad.com. The assessor was the nurse and the physiotherapist of the ward, both blinded to the study groups. The patient and the surgeon were also blinded to the study group allocation.

In Group A, 20 ml ropivacaine (0.375%) but in Group B and Group C along with 20ml ropivacaine (0.375), 0.25 µg/kg dexmedetomidine and 0.5 µg/kg dexmedetomidine was administered respectively. Patients were positioned with the lower limb of the operated side slightly abducted at the hips and flexed at the knees. At mid-thigh level, an ultrasound-guided ACB was performed using a linear ultrasound probe (7 L4P, 5–10 MHz; Mindray Z 6, Shenzhen Mindray Biomedical Electronics Ltd, Shenzhen, China) and a 21-gauge 10 cm short beveled needle (Stimuplex™, B Braun Medical) in plane with the transducer, from lateral to medial (Figure 1) with the needle tip targeted anterolateral to the femoral artery and below the Sartorius muscle (Figure 2). A bolus of 2 ml of normal saline was used to confirm the location of needle tip. A volume of 20 ml of block solution was injected in 5 ml aliquots through the injection port of the needle after negative aspiration. The spread of the drug between the sartorius and the femoral artery was seen real time on ultrasound (Figure 3).

The patients were observed for 60 minutes and Heart rate (HR), non-invasive blood pressure (NIBP) and oxygen saturation (SpO₂) were monitored continuously at 15 min



Fig. 1: Approach of adductor canal block (ACB) b using USG probe and Stimuplex™ needle

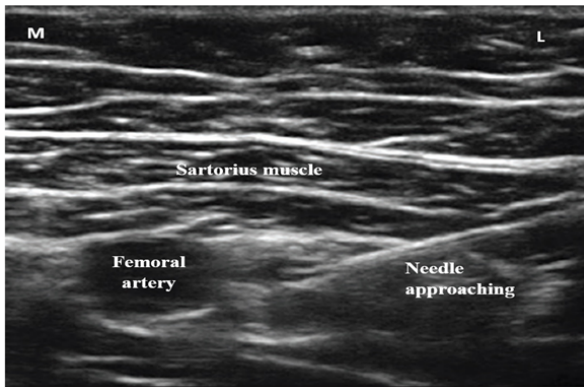


Fig. 2: USG image of femoral artery and needle approach for adductor canal block



Fig. 3: USG image of femoral artery and local anaesthetic spread after adductor canal block

interval for the 1st hour after the block and then 6-hourly for the next 24 hours.

Sedation score was assessed using Ramsey Sedation scale (RSS) at 15,30, 45 and 60 minutes after ACB and then at an interval of 6 hours up to 24 hours. Numeric Rating Scale (NRS; 1–10, 1 being the least and 10 being the worst pain described by the patient) was used to assess pain at 6, 12, 18 and 24 hours timepoints during the post-operative period. Intravenous tramadol 100 mg and Ondansetron 4mg was administered to patients as rescue analgesia after ACB. Time to first rescue analgesia and the total tramadol consumption in 24 hours were noted. The ward nurse collected the data in the post-operative period such as HR, NIBP and SpO₂. Bradycardia and hypotension were defined as 20% decrease from the baseline HR and mean arterial pressure respectively and were treated with atropine and intravenous fluid boluses. Any adverse event such as shivering, giddiness, nausea, vomiting, paresthesia, local pain and signs of local anaesthetic systemic toxicity were noted during the study. A physiotherapist assessed quadriceps motor strength by straight leg raise (SLR) on a 0–5 scale (0 being no muscle contraction and 5 being the normal strength) pre-operatively and then after 24 hours of ACB as per the Medical Research Council (MRC) scale.

The patients were assisted to ambulate when motor strength was ≥ 2 after 24 hours of ACB and the number of steps that the patient could walk were noted. The patient satisfaction score after 72 hours of ACB was also noted as a qualitative manner; 1 - not satisfied, 2 – satisfied and 3 -better than expected. At this time, the patients were also asked about any paresthesia, numbness or pain in the thigh.

The CONSORT flow diagram for the study has been mentioned in Figure 4. The collected data was analyzed using the IBM Statistical Package for Social Science (SPSS 24.0 version, IBM Corp., Armonk, N.Y., USA) and it was normally distributed as assessed by Shapiro-wilk test. Quantitative variables like age of the patients, BMI, duration to rescue analgesia, total opioid consumption, NRS, RSS and MRC scores were expressed as mean \pm standard deviation (SD) and compared using ANOVA as well as Bonferroni post-hoc analysis. Qualitative variables like patient satisfaction and incidence of adverse events were expressed as frequencies and percentages. They were compared using Chi-square test or Fisher’s exact test whenever appropriate. A p-value less than 0.05 was considered statistically significant.

3. Results

Demographic variables like age and BMI were comparable between the groups (Table 1). Duration to rescue analgesia was significantly longer and total opioid consumption was significantly lower in Group C (Table 1). In Bonferroni post-hoc analysis, there was no significant difference between Group A and B with respect to duration to rescue analgesia

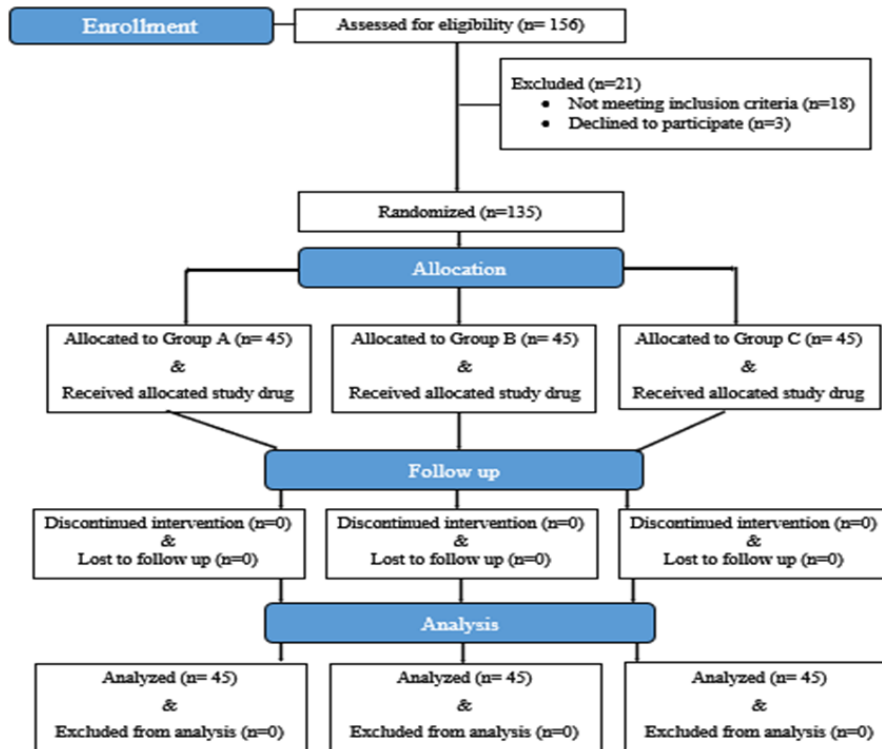


Fig. 4: CONSORT Flow Diagram of the study

($p=0.871$) and total opioid consumption ($p=0.733$). NRS scores at rest (Figure 5) were significantly different only at 18 and 24 hours (Table 2) after ACB whereas NRS scores with movement were significantly different at 12, 18 and 24 hours timepoints (Table 3). Mean MRC score in patients of Group A, B and C were 2.40 ± 0.50 , 2.82 ± 0.66 and 3.09 ± 0.81 respectively ($p=0.003$). Mean steps walked during ambulation were higher in group C but it could not reach the statistical significance level [Group A: 10.76 ± 3.62 ; Group B: 11.71 ± 4.12 ; Group C: 13.22 ± 4.41 ($p=0.052$)]. Patient satisfaction was significantly higher in Group C with 46.67% patient reporting better than expected peri-operative experience ($p=0.022$) (Figure 6). RSS scores, mean HR, mean arterial pressure values (MAP) and SpO_2 were comparable between all the groups even after Bonferroni post-hoc analysis. There was no adverse events reported in any of patients included in the study.

4. Discussion

Increasing incidence of osteoarthritis even in middle age groups has led to rising rates of TKR surgeries. The period after total knee replacement (TKR) surgery is known to be painful for the first 24 hours, lasting up to 3 days in many cases. Adequate analgesia following TKR is paramount to early recovery, rehabilitation and timely discharge.

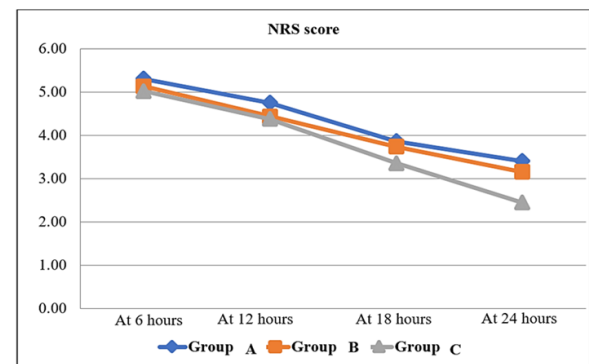


Fig. 5: NRS scores at rest in all 3 groups

Therefore, early postoperative analgesic and rehabilitation goals are intricately related.

Until now, different techniques have been used, including intravenous narcotic pain medication, continuous femoral nerve block and epidural analgesia. These are all effective methods but each is limited by side effects. For years, femoral nerve block (FNB) has been considered as the main peripheral nerve block for postoperative analgesia following knee surgery. However, quadriceps weakness as the major downside of FNB led to search for alternative nerve blocks. In recent years, ACB has gained lots of popularity as

Table 1:

Parameters	Group (n=45)	Mean	Standard deviation	p-value
Age	A	64.04	10.91	0.518
	C	64.09	10.98	
BMI	A	61.84	9.83	0.751
	C	26.38	2.03	
Duration to rescue analgesia (hours)	A	26.11	1.75	0.014
	C	26.38	2.00	
Total Opioid Consumption (mg)	A	15.71	4.87	0.033
	C	16.44	6.21	
	A	19.78	5.57	
	A	60.00	13.94	
	C	52.22	18.80	
	C	33.33	13.95	

Table 2:

NRS score at rest	Group (n=45)	Mean	Standard deviation	p-value
At 6 hours	A	5.31	0.87	0.491
	C	5.13	1.08	
At 12 hours	A	5.02	1.44	0.225
	C	4.76	1.07	
At 18 hours	A	4.44	1.03	0.022
	C	4.38	1.19	
At 24 hours	A	3.87	0.92	<0.001
	C	3.73	0.96	
	A	3.36	0.80	
	A	3.40	0.94	
	C	3.16	1.13	
	C	2.44	0.76	

Table 3:

NRS score with movement	Group (n=45)	Mean	Standard deviation	p-value
At 6 hours	A	5.93	1.07	0.480
	C	5.76	1.11	
At 12 hours	A	6.07	1.44	0.001
	C	5.53	1.20	
At 18 hours	A	5.44	1.14	<0.001
	C	4.62	1.39	
At 24 hours	A	4.73	1.25	<0.001
	C	4.64	0.80	
	A	3.78	0.95	
	A	4.00	1.28	
	C	3.82	1.09	
	C	3.02	0.78	

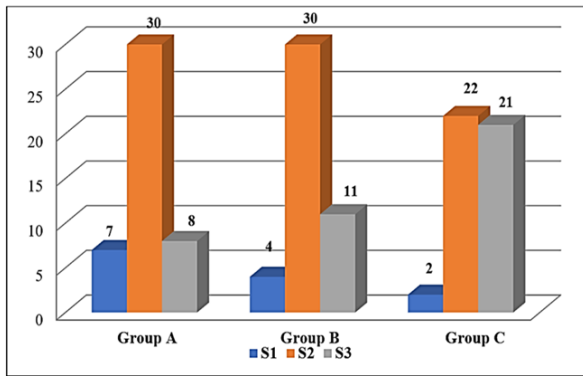


Fig. 6: Overall patient satisfaction in all 3 groups

it minimizes quadriceps muscle weakness while giving adequate pain relief after surgery. Addition of opioid sparing adjuvants like dexmedetomidine may further be of benefit.

Thus we conducted this study with the aim to compare the duration of analgesia of adductor canal block using ropivacaine alone versus ropivacaine with two different doses of dexmedetomidine after unilateral total knee replacement and the secondary outcomes were the total opioid consumption, success of early ambulation, level of patient satisfaction, and any adverse effects following the study interventions.

Several studies have shown good analgesia and better quadriceps strength with ACB for unilateral TKR.^{1,5–8} The main nerve blocked in the adductor canal is saphenous nerve, the main sensory nerve. Other nerves such as nerve to vastus medialis, obturator nerve (articular branches), medial femoral cutaneous nerve, and medial retinacular nerve also traverse through the adductor canal and will have a motor component.⁴ Ropivacaine have a lesser motor blockade as it is less lipophilic than bupivacaine and penetrate less to large myelinated motor fibres and thus, we hypothesised that there would be better ambulation after surgery.⁹

Dexmedetomidine is a highly selective, specific, and potent α -2 adrenergic receptor agonist that has anxiolytic, sedative, analgesic, sympatholytic properties and anti-hypertensive.¹⁰ Many studies have demonstrated that dexmedetomidine combined with local anesthetics can improve the postoperative analgesic effect and further prolong the duration of analgesia after TKR.^{11,12} The doses of dexmedetomidine used in this study were chosen keeping in mind both safety as well as efficacy of this drug.

Duration to rescue analgesia was significantly higher in group C compared to group A and the results were similar to observations made by other investigators.^{13,14} Sharma B et al. concluded that 0.2% ropivacaine with dexmedetomidine 1.5 μ g/kg in femoral nerve block in patients undergoing unilateral TKR prolonged the duration of post-operative analgesia but there was significant decrease in systolic and mean blood pressure post-surgery till 4 and 8 hours.¹⁵ In

view of the potential adverse effects of high dosages, we used dexmedetomidine 0.25 μ g/kg and 0.5 μ g/kg.

Total opioid consumption was significantly less in group C as compared to group A in present study and similar observations were made by other investigators.^{15,16} In our study, total opioid consumption was significantly less 0.5 μ g/kg in group C than the group A with no dexmedetomidine.

There was no significant difference in the sedation score between the three groups at all-time points. Chun-Guang Wang et al concluded that dexmedetomidine 1 μ g/kg with 0.5% ropivacaine resulted in significant sedation in lumbar plexus and sciatic nerve block compared to ropivacaine alone.¹⁷

Pain score at rest was significantly lower in group C as compared to group A (at 18 hours and 24 hours) and group B (at 24 hours). Pain score at movement in group C is significantly lower than group A and group B at 12, 18 and 24 hours. Pan L et al. also concluded that pain scores significantly decreased at different time points postoperatively when dexmedetomidine was used an adjunct to nerve blocks.¹⁸

Motor strength was important factor to keep track of for the patients as well as for the surgeons because early rehabilitation is essential and helpful for the success of TKR. Dexmedetomidine combined with local anesthetics in nerve block could increase motor strength compared to local anesthetics alone.¹⁸ This is likely due to the fact that dexmedetomidine can inhibit the local anesthetics to penetrate the motor fibre. Motor strength on both sides in group C is significantly higher than group A. Steps walked and Satisfaction score is significantly higher in group C. The results were similar to the study done by Goyal R et al. using dexmedetomidine in doses 0.25 μ g/kg & 0.5 μ g/kg with 0.375% ropivacaine in adductor canal block after bilateral TKR surgery.¹⁹

There was no significant difference in heart rate between the three groups at all time points. There was no significant difference in systolic BP and diastolic BP between the three groups at all time points except at time point 9 where systolic BP in group A was significantly higher than group C, which was apparently of no clinical significance.

Our study has shown the efficacy of ultrasound guided adductor canal block as an analgesic modality to promote early ambulation in patients undergoing unilateral TKR surgery and also validates the efficacy of dexmedetomidine (0.5 μ g/kg) as adjuvant to ropivacaine in adductor canal block for prolonging the duration of analgesia without haemodynamic compromise or temporary motor deficit. Better analgesia, lower opioid consumption, better ambulation and minimal adverse effects are the possible contributory factors for better patient satisfaction.

Our study findings were also suggestive of the fact that 0.50 μ g/kg is the adequate dose for providing analgesia after

TKR whereas 0.25 µg/kg was associated with early need of rescue analgesics.

Limitation of the study was the multimodal analgesia (oral paracetamol, pregabalin and etoricoxib) which were used as per institutional protocol. These medications might have reduced requirement of dexmedetomidine and may have potentiated the effects of dexmedetomidine.

5. Conclusion

The addition of dexmedetomidine as an adjuvant, at a dose of 0.5 µg/kg to 0.375% ropivacaine in adductor canal block results in longer duration of analgesia, less 24 hours opioid consumption, better motor strength and better patient satisfaction without any adverse effect after unilateral total knee replacement surgery.

6. Source of Funding

None.

7. Conflicts of Interest

None of the authors have any conflicts of interest to declare.

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Cite this article: Chattopadhyay A, Parashar P, Kumar A, Kohli A, Teckchandani C, Gupta L. Evaluation of postoperative analgesic efficacy of dexmedetomidine as adjuvant with ropivacaine in ultrasound guided adductor canal block in patients undergoing unilateral Total Knee Replacement. *Indian J Clin Anaesth* 2022;9(1):105-111.