Section: Anaesthesiology

Original Research Article

EFFECT OF DEXMEDETOMIDINE AS ADJUVANT TO ROPIVACAINE IN ULTRASOUND GUIDED ADDUCTOR CANAL BLOCK FOR POSTOPERATIVE ANALGESIA IN ARTHROSCOPIC KNEE SURGERY

Aysha Nubla[1], Bashith Puthukkudi[2], Leya Mariam Varghese[3], Jyotsna M Jose[4]

[1]*Assistant Professor, Department of Anaesthesiology, KMCT Medical College, Kozhikode, India.*
[2]*Assistant Professor, Department of Anaesthesiology, Dr Moopen's Medical College, Wayanad, Kerala, India.*
[3]*Assistant Professor, Department of Anaesthesiology, Government Medical College, Kozhikode, India.*
[4]*Consultant Anaesthesiologist, St. Thomas Hospital, Chethipuzha Kottayam, India.*

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Corresponding Author:
Dr. Aysha Nubla,
Assistant Professor, Department of Anaesthesiology, KMCT Medical College, Kozhikode, India
Email: draysha.nubla@gmail.com.

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ABSTRACT

Background: Peripheral nerve blocks are an important part of multimodal approach to postoperative analgesia. Dexmedetomidine, an α2-adrenergic agonist, when used as adjuvant to local anesthetics in peripheral nerve blocks, improves the speed of onset and duration of analgesia. The aim was to study the effect of dexmedetomidine as an adjuvant to ropivacaine in ultrasound guided adductor canal block for postoperative analgesia following arthroscopic knee surgeries. The time to first rescue analgesic, total consumption of rescue analgesic and Numerical Rating Scale (NRS) score during rest and movement in 24 hours were studied.

Material and Methods: A prospective cohort study was conducted in 92 patients, aged 18-60 years, belonging to American Society of Anaesthesiologists (ASA) physical status I and II, scheduled for arthroscopic knee surgery. They were randomly divided into two equal groups using a computer-based random number table. After surgery, soon after reaching the PACU, Group A received ultrasound guided adductor canal block with 15 mL 0.5% ropivacaine and 2 mL dexmedetomidine (1 µg/kg), whereas Group B received 15 mL 0.5% ropivacaine and 2 mL normal saline. The mean time for rescue analgesic, total rescue analgesic consumption, Numerical Rating Scale (NRS) score, haemodynamic parameters and adverse effects (if any) were noted for 24 hours post- operatively. Statistical analysis was done using SPSS version 24. Qualitative data were compared using Chi square test and quantitative data were compared using independent sample t-test. Significance was defined as $p < 0.05$.

Results and Discussion: Group A had significantly prolonged duration of analgesia compared to group B. There was significant difference between mean time for first rescue analgesic between the groups ($p < 0.001$). Total postoperative analgesic consumption and pain score were less in Group A ($p < 0.001$) than Group B for the first 24 hours.

Conclusion: From this study it was concluded that the use of dexmedetomidine as adjuvant to ropivacaine for ultrasound guided adductor canal block provides superior postoperative analgesia than ropivacaine alone in patients undergoing arthroscopic knee surgery. It also reduces postoperative rescue analgesic consumption and provides better patient satisfaction without significant adverse effects.

Keywords: Ropivacaine; Dexmedetomidine; Adductor canal block; Arthroscopic knee surgery; Postoperative analgesia.

INTRODUCTION

The incidence of athletic knee injuries has increased in the last few decades and they result in significant disability. The anterior cruciate ligament (ACL) is the most common ligament to be injured. The ACL is often stretched and torn during a sudden twisting motion. Skiing, basketball, and football are sports that have a high risk for ACL injuries. Since most of the patients belong to the young age group, prompt intervention in the form of ACL reconstruction is necessary to resume physical activity as well as athletic career in some. For the same reason, faster recovery and shorter hospital stay are desired. Acute pain after arthroscopic reconstruction of ACL can last up to 48 hours and result in poor outcome due to late recovery, prolonged hospital stay, inability to participate in rehabilitation programmes and increased use of health resources. Inadequate pain relief in the postoperative period leads to poor mobility, resulting in the development of adhesions, weakened ligament insertion and muscle atrophy.[1,2]

Multimodal approach to pain relief is recommended nowadays, as adverse effects of individual drugs can be minimised. It includes intravenous and intraarticular nonsteroidal anti-inflammatory drugs and opioids, neuraxial blocks and peripheral nerve blocks. Several studies have shown that peripheral nerve blocks are effective, with potentially less morbidity than central neuraxial techniques like epidural analgesia which have more frequent episodes of hypotension, dizziness and urinary retention and warrant strict postoperative monitoring.[3]

Understanding the innervation of the knee joint has led to the concept of blocking the saphenous nerve at the adductor canal for analgesia. Adductor canal block under ultrasound guidance is a relatively novel technique with a high success rate. Its motor sparing property makes it attractive for ambulatory knee surgeries like total knee arthroplasty and arthroscopic knee procedures, compared to other peripheral nerve blocks like femoral nerve block and obturator nerve blocks. It reduces pain and thereby opioid consumption after knee arthroscopy. Many studies have proved its role in early mobilisation after total knee repair as well.[2,4,5]

Local anaesthetics such as ropivacaine and bupivacaine in various concentrations are used in peripheral nerve blocks. Though the analgesic efficacy of ropivacaine and bupivacaine are comparable, ropivacaine has better neurological and cardiovascular safety profile in case of an accidental intravascular injection. It also has less motor block compared to bupivacaine.[6]

Different adjuvants can be added to local anaesthetics which improve the quality and duration of analgesia, reduce the need for postoperative opioids and associated complications. They can also reduce the duration of hospital stay. They include clonidine, dexmedetomidine, magnesium sulfate, opioids, neostigmine, dexamethasone, etc. Opioids are associated with various side effects and complications like sedation, constipation, dependence, tolerance, respiratory depression etc., so opioid free analgesia is preferred nowadays.[7,8]

Dexmedetomidine is an alpha 2-adrenergic agonist that provides sedation, anxiolysis and analgesia with much less respiratory depression than other sedatives. Systemic administration and use as adjuvant to local anaesthetic through various routes have been found to be effective in prolonging the post-operative analgesic effect after general anaesthesia, central neuraxial blockade as well as peripheral nerve blocks.[9,10] Its mechanism of action is similar to clonidine, however dexmedetomidine is 7–8 times more alpha-2 selective than clonidine. Dexmedetomidine acts at alpha-2a receptors in the locus coeruleus of brain and spinal cord and it attenuates nociceptive signal transduction. By this mechanism, the drug produces its central analgesic effects.[11,12]

In this study, we aim to study the effect of dexmedetomidine as an adjuvant to ropivacaine in ultrasound guided adductor canal block for postoperative analgesia following arthroscopic knee surgeries.

Aim

To study the effect of dexmedetomidine as adjuvant to ropivacaine in ultrasound guided adductor canal block for postoperative analgesia following arthroscopic knee surgeries.

Objectives

Primary Objective

To compare the duration of postoperative analgesia in the two groups using:

1. Time to first rescue analgesic
2. Total consumption of rescue analgesic in 24 hours
3. Numerical Rating Scale (NRS) score during rest and movement

Secondary Objective

To study the incidence of adverse effects such as sedation, hypotension, bradycardia, nausea and vomiting.

MATERIALS AND METHODS

Study Design

Prospective cohort study

Study Setting

Government Medical College, Kozhikode

Study Period

January 2020 to October 2021

Study Population

Patients undergoing arthroscopic knee surgery

Sample Size

Sample size calculation is done using the formula.

$$n = \frac{(Z\alpha+Z\beta)^2 \, SD^2 \, 2}{d^2}$$

where Zα =1.96, Zβ = 0.84, d = effect size = 3.
As per the study conducted by Thapa D et al,[2] SD (Standard deviation) = 5.12 and d =3. So, n=46
Therefore, in this study, the sample size calculated is 46 subjects in each group.

Inclusion Criteria

1. Patients posted for knee arthroscopic surgeries
2. ASA physical status class I – II
3. Age between 18-60 years
4. BMI ≥20, ≤30 kg/m2

Exclusion Criteria

1. Patient refusal
2. History of drug abuse
3. Psychiatric disease
4. Peripheral neuropathy
5. Pre-existing bleeding disorders
6. Allergic reaction to local anaesthetics, opioids and/or dexmedetomidine
7. Pregnancy, lactation
8. Infection at the site of block
9. Conversion to general anaesthesia

Materials and Methods

After getting ethical committee clearance, all patients were assessed by a detailed preanaesthetic check up with history taking, physical examination and laboratory investigations and basic data were recorded. An informed written consent was obtained from patients for participation in study in their native language. All patients were kept nil per oral before surgery (8 hours for solid foods and 2 hours for clear fluids). Patients were brought to the premedication room on the day of surgery and baseline heart rate, blood pressure, oxygen saturation were recorded. All patients received tablet alprazolam 0.25 mg night before surgery, tablet ranitidine 150 mg and metoclopramide 10 mg on night before and morning of surgery.

In the operating room, after confirming patient identity and consent and attaching monitors which include electrocardiogram, pulse oximetry, non-invasive blood pressure, an intravenous access was established and supplemental oxygen at 5 L/min via face mask was given. All patients were given IV midazolam 1 mg to decrease anxiety and preloaded with 500 ml 0.9% Normal Saline. All patients were given subarachnoid block with 3 ml 0.5% bupivacaine (H) at L3-L4 space using 23G Quincke's needle in lateral decubitus position such that a sensory and motor blockade of at least L1 level was attained.

Intraoperatively patients were monitored throughout, and vitals recorded. IV fluids were given to ensure haemodynamic stability. Intraoperative complications such as hypotension, bradycardia, and nausea/vomiting were documented and managed according to standard protocol.

Soon after reaching the PACU after surgery, the patients received ultrasound- guided adductor canal block as described below:

In supine position, under aseptic technique with guidance of ultrasound (Sonosite SII), using a high frequency linear transducer at the midportion between the anterior superior iliac spine and the patella, the adductor canal was visualised.

Saphenous nerve was visualised just deep to the sartorius muscle lateral to femoral artery as a hyperechoic structure. With the tip of the needle placed just lateral to the artery and the saphenous nerve, 15 ml 0.5% ropivacaine + 2 ml dexmedetomidine or normal saline was injected to expand the adductor canal.

Patients were randomly allocated into two equal groups using a computer-generated random number table.

Each group had 46 subjects

Group A: Patients received adductor canal block with 15 ml 0.5% ropivacaine + 2 ml dexmedetomidine (1 µg/kg).

Group B: Patients received adductor canal block with 15 ml 0.5% ropivacaine + 2 ml normal saline.

Two anaesthesiologists were involved in the study. All these procedures were done by an experienced anaesthesiologist and the second person, who was blinded to the group allocation, carried out the observations.

The outcome of this study was measured by assessing the postoperative analgesia and early ambulation status in both groups. Postoperative analgesia was measured by Numerical Rating Scale (NRS) score which represents their current state of pain with "0" mark corresponding to no pain and "10" mark representing worst imaginable pain, every 4 hours starting immediately after block for 24 hours. Time of first rescue analgesic administration and total rescue analgesic consumed in 24 hours postoperatively were noted. The following parameters were observed and recorded:

- Pain assessment by Numerical Rating scale (NRS) during rest and movement.
- Time to first rescue analgesic / duration of analgesia.
- Total consumption of rescue analgesic in 24 hours. Postoperatively all patients received 1 g paracetamol IV 6th hourly and rescue analgesia with Inj. Tramadol 50 mg IV will be given if patients complain of pain and NRS score more than 4.
- Patients were also be observed for any adverse effects such as postoperative nausea with or without vomiting, skin rash (redness or itching), hypotension (defined as blood pressure <20% of baseline values), sedation (by Ramsay sedation scale), respiratory depression (defined as respiratory rate less than 10/min), need for supplemental oxygen (saturation <93%), bradycardia (heart rate <60 beats/min), block failure, any neurological complications and any redness or signs of inflammation at skin puncture site.
- Patient satisfaction was graded as:
- Poor – 1
- Moderate – 2
- Good – 3

- Excellent – 4

Statistical Analysis

All data were analysed using SPSS version 24. Qualitative data of two groups were analysed using proportions and compared using Chi-square test. Quantitative data of two groups were presented as mean and standard deviation and compared using independent sample t-test. Significance was defined as $p < 0.05$.

RESULTS

Demographic variables were compared between the two groups by Pearson Chi-square statistics. Both the groups were comparable with respect to age, sex, weight, height, BMI and ASA status. There was no statistically significant difference. ($p > 0.05$).

Table 1: Comparison of demographic details

Variables		Groups		p value
		A (N=46)	B (N=46)	
Age (years)	Mean	25.98 ± 5.515	26.15 ± 7.309	0.898
Weight (kg)	Mean	67.34 ± 7.701	68.02 ± 6.945	0.660
Height (cm)	Mean	168.22 ± 7.360	169.76 ± 6.063	0.275
BMI (kg/m^2)	Mean	23.73 ± 1.186	23.55 ± 1.186	0.446
Sex (M/F)	M	40 (87%)	43 (93.5%)	0.726
	F	6 (13%)	3(6.5%)	
ASA (I/II)	I	46 (100%)	45 (97.8%)	0.315
	II	0 (0%)	1 (2.2%)	

The mean time required for first rescue analgesic in Group A and Group B were compared using independent sample t-test and were 20.13 hours and 9.65 hours respectively. There was a statistically significant difference between the two groups ($p< 0.001$).

The total rescue analgesic required in 24 hours was compared between both the groups using independent sample t-test. The mean total dose of rescue analgesic requirement in Group A & Group B were 1.00 (50 mg tramadol) & 2.09 (104.5 mg tramadol) respectively. This difference was statistically significant with p value < 0.001.

Mean Numerical Rating Scale (NRS) score at rest for 24 hours and mean Numerical Rating Scale (NRS) score at movement was higher in Group B, but the difference at the end of 24 hours was not statistically significant ($p = 0.366$).

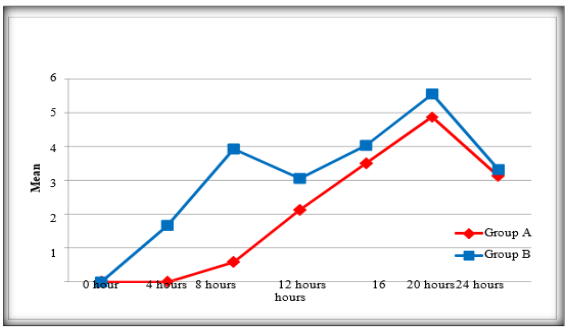

Figure 1: Comparison of mean Numerical Rating Scale (NRS) score at rest for 24 hours between the two groups

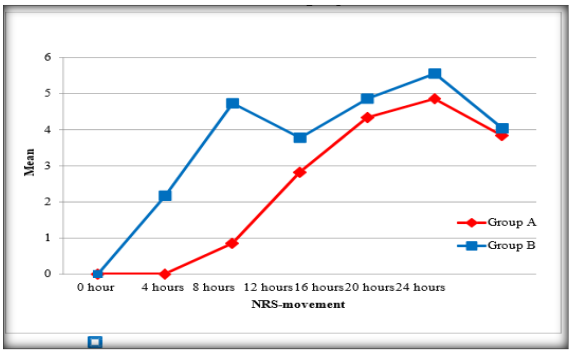

Figure 2: Comparison of mean Numerical Rating Scale (NRS) score at movement for 24 hours between the two groups

Mean satisfaction score was statistically significant with $p < 0.001$. 8.7%, 78.3% and 13% patients in Group A had a satisfaction score of 2,3 and 4 respectively. In group B, 32.6% and 67.4% had satisfaction score 1 and 2 respectively.

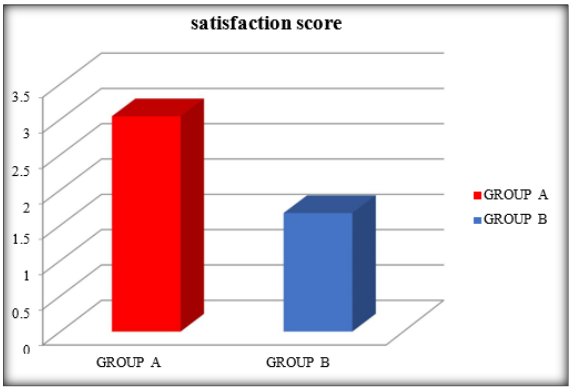

Figure 3: Satisfaction score at 24 hours

Adverse effects within 24 hours after surgery were compared in both the groups using Pearson Chi-square test. Group A had less complications. 6.5% of patients had nausea. None of the patients in Group A had vomiting. In Group B, 15.2% of

patients had nausea and 4.3% of patients had vomiting. However, the difference was not statistically significant (p value = 0.132).

DISCUSSIONS

Adductor canal block following arthroscopic knee surgeries has been observed as an effective technique for postoperative pain relief. It can be used as a part of a multimodal approach. It also favours early mobilisation and shorter hospital stay. Various adjuvants are being added to local anaesthetics for faster onset of action and prolonged duration of analgesia. By adding dexmedetomidine, an alpha-adrenergic agonist to local anaesthetic, patients remain pain-free for longer duration, with fewer opioid related side effects. There have been several studies comparing the efficacy of dexmedetomidine when added to local anaesthetics for peripheral nerve blockade.

In the present study, we studied the effect of dexmedetomidine as an adjuvant to ropivacaine for ultrasound guided adductor canal block in arthroscopic knee surgeries done under subarachnoid block. Group A received adductor canal block with 15 mL 0.5% ropivacaine and 2 mL normal saline whereas Group B received 1 5mL 0.5% ropivacaine with 1 µg/kg dexmedetomidine (2 mL). We analysed time to first rescue analgesic, total rescue analgesic requirement, pain scores and side effects.

I. Demographic variables

Demographic variables like age, sex, height, weight, BMI and ASA status were comparable in both the groups with no statistically significant difference. (p > 0.05). Most of the patients belonged to the young age group with a mean of 25.98 years in Group A and 26.15 years in Group B. The study had a higher proportion of male patients in both the groups. (87% in Group A and 93.5% in Group B). Majority of the patients were of ASA physical status class I.

II. Time to first rescue analgesic:

The time required for first rescue analgesic consumption in Group A (20.13 hours) was significantly higher than that in Group B (9.65 hours), with a p value < 0.001.

In a similar study conducted by Thapa D et al,[2] comparing the analgesic efficacy of dexmedetomidine as adjuvant to ropivacaine in ultrasound guided adductor canal block, following anterior cruciate ligament surgeries, the time to first rescue analgesic was found to be significantly higher (7.14 hours) in perineural dexmedetomidine group than in ropivacaine group (4.43 hours) with a p value <

0.001. The values in both the groups were low compared to the corresponding groups in our study. The shorter duration of analgesia in the dexmedetomidine group may be

because a lower dose of dexmedetomidine was used. (0.5µg/kg). Thus, we observed that a higher dose of dexmedetomidine may provide longer duration of analgesia when used in adductor canal block.

In another study conducted by Kathuria S et al,[13] for assessing the effect of dexmedetomidine as adjuvant to ropivacaine for supraclavicular brachial plexus block in upper limb surgeries, the duration of analgesia with perineural dexmedetomidine was found to be around 16 hours (967.55 minutes) when 50 µg dexmedetomidine was used and 9 hours (536.75 minutes) when ropivacaine alone was used (p < 0.001), which was similar to our study.

In a study conducted by Jung HS et al,[14] investigating optimal dose of dexmedetomidine in interscalene brachial plexus block for postoperative analgesia in patients undergoing arthroscopic shoulder surgery, the duration of analgesia with 1 µg/kg, 1.5 µg/kg and 2 µg/kg dexmedetomidine as adjuvant to 0.5% ropivacaine were

17.2 hours, 17.4 hours and 20.38 hours respectively and 13.47 hours without dexmedetomidine. There was significant improvement in duration of analgesia when the dose of dexmedetomidine was increased (p < 0.001).

A study conducted by Rashmi HD et al,[15] compared the effect of dexmedetomidine as adjuvant to 0.75% ropivacaine for interscalene brachial plexus block in upper limb surgeries and the duration of analgesia was found to be significantly higher (p < 0.0001) when 50 µg dexmedetomidine was added (14.87 hours), compared to ropivacaine alone (9.83 hours).

In the study conducted by Abdulatif M et al,[10] the time to first request for postoperative analgesia were 10.8 hours in the control group (0.5% bupivacaine) and 11 hours, 21.8 hours and 28.6 hours in the 25µg, 50µg and 75µg treatment groups, respectively indicating the effect of dexmedetomidine on duration of analgesia (p < 0.0001). This was similar to the results in our study.

III. Total rescue analgesic requirement in 24 hours

IV tramadol 50 mg was given as rescue analgesic when the Numerical Rating Scale (NRS) score was above 4. The total rescue analgesic required in 24 hours in Group A and Group B were 1.00 (50 mg tramadol) and 2.09 (104.5 mg tramadol) respectively and the difference was statistically significant (p < 0.001). This shows that total analgesic requirement was reduced by the addition of dexmedetomidine to

ropivacaine for adductor canal block.

In the study conducted by Thapa D et al,[2] the mean morphine consumption was observed to be 5 mg in the perineural dexmedetomidine group and 8.25 mg in the ropivacaine group and the difference was statistically significant (p < 0.05).

Similar results were obtained from the study conducted by Kathuria S et al,[13] where injection diclofenac 75mg IM was given as rescue analgesic when Visual Analogue Scale (VAS) score was ≥4. The total rescue analgesic consumption in 24 hours was 56.25 mg in the dexmedetomidine group and

120 mg in the ropivacaine group and the difference was statistically significant ($p < 0.001$).

In the study conducted by Helal SM et al,[16] 100 µg dexmedetomidine was added to 0.5% bupivacaine in femoral-sciatic nerve block, where the dose of dexmedetomidine was higher than that in our study. The total rescue analgesic (tramadol) consumption in 24 hours was 240 mg in the bupivacaine group and 100 mg in the dexmedetomidine group with a p value < 0.01.

Abdulatif M et al,[10] also reported in their study that the total morphine consumption was significantly lower ($p < 0.0001$) in the 50 µg (3.9 mg morphine) and 75 µg (1.8 mg morphine) dexmedetomidine groups than the control group (7.6 mg morphine).

In contrast to above studies, there was no significant difference in total rescue analgesic consumption in any of the groups in the study conducted by Jung HS et al.[14]

IV. Numerical Rating Scale (NRS) score at rest and movement for 24 hours

The mean Numerical Rating Scale (NRS) scores at rest and movement at 0 hour, 4 hours, 8 hours, 12 hours, 16 hours, 20 hours and 24 hours were noted. Immediately after giving adductor canal block, the mean Numerical Rating Scale (NRS) score at rest and movement was 0 in both the groups. After that, the mean Numerical Rating Scale (NRS) score at rest and movement was higher in Group B than in Group A till 20 hours ($p < 0.05$) and the difference was highly significant up to 12 hours ($p < 0.001$). But at the end of 24 hours, there was no statistically significant difference among the two groups.

The study conducted by Jung HS et al,[14] also showed similar results, where

there was significant lowering of Numerical Rating Scale (NRS) score in the dexmedetomidine group at 12 hours ($p < 0.01$), but there was no statistically significant difference at 24 and 36 hours after an interscalene block.

In the study conducted by Thapa D et al,[2] Visual Analogue Scale (VAS) scores at rest and on movement 0, 5, 10, 15, 20, 30 and 60 minutes and at 2, 4, 6, 8, 12 and 24 hours were noted and were comparable in all the three groups. There was no statistically significant difference ($p > 0.05$).

V. Satisfaction score

Higher mean satisfaction score at 24 hours was observed in the dexmedetomidine group with a mean of 3.04 which indicates excellent patient satisfaction ($p < 0.001$).

However, in the study conducted by Thapa D et al,[2] there was no difference in mean satisfaction scores in any group, owing to the use of multimodal analgesic regimen. ($p > 0.05$)

VI. Adverse effects

The incidence of adverse effects was studied in both the groups. Respiratory depression or a fall in SpO2 were not reported in any of the patients. The patients in both the groups had a Ramsay sedation score of 2 (awake, co-operative and accepting ventilation).

Nausea was observed in 3 patients in Group A and 7 patients in Group B. 2 patients in Group B and none of the patients in Group A experienced vomiting. However, this difference was not statistically significant ($p > 0.05$). There was no hypotension, bradycardia, or hypoxia in any group.

In the study conducted by Thapa D et al,[2] sedation was higher in IV dexmedetomidine group as compared to perineural dexmedetomidine or control group for initial 20 minutes ($p = 0.003$). However, all subjects remained drowsy but arousable. There were no adverse effects, that is, hypotension or bradycardia observed during the study. Nausea and vomiting were not reported by any of the subjects in their study. Jung HS et al,[51] and Abdulatif M et al,[10] reported significant hypotension and Helal SM et al noticed significant bradycardia in their studies when higher dose of dexmedetomidine (>1 µg/kg) was used ($p < 0.05$).

Limitations of the Study

- Numerical Rating Scale is used for assessing pain, which is subjective and may vary from patient to patient.
- A randomised controlled trial would be a better study design.
- A small sample size was studied

CONCLUSION

From this study, it was concluded that the use of dexmedetomidine as adjuvant to ropivacaine provides better postoperative analgesia than ropivacaine alone for ultrasound guided adductor canal block in patients undergoing arthroscopic knee surgeries.

There was lower rescue analgesic consumption, lower pain score and better patient satisfaction with dexmedetomidine.

Adverse effects like sedation, bradycardia and hypotension were not observed in either group. Nausea and vomiting were less when dexmedetomidine was used.

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