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Research Article

Comparison of Two Doses of Dexmedetomidine as Adjuvant to Ropivacaine in Ultrasound Guided Adductor Canal Block: Randomised Double-Blind Controlled Trial

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ABSTRACT

Background: Adjuvants to local anesthetics (LA) have proven to prolong the analgesic efficacy of Adductor canal block (ACB). The ACB when administered with lower dose of LA produces analgesia without loss of motor control of the thigh. Hence we studied the efficacy of two different doses of dexmedetomidine in ACB to prolong postoperative analgesia when used as adjuvant to ropivacaine.

Methods: Total of 90 patients between 18-65years undergoing arthroscopic ligament reconstructions surgeries of knee were randomized into three groups and given Ultrasound guided (USG) ACB. Group A - 0.2% Ropivacaine, Group B – 0.2% Ropivacaine plus Dexmedetomidine 0.50 mcg.kg^{-1} and Group C- 0.2% Ropivacaine plus Dexmedetomidine 1 mcg.kg^{-1}. Primary aim of our intervention was to study the duration of post-operative analgesia and Secondary aim was to study the total dose of rescue analgesic required in 24hrs, success of early ambulation, level of patient satisfaction and any adverse effects.

Results: The duration of analgesia was found highest in Group C (1166 ±200mins) than Group A (420±100mins) and Group B (702± 150mins). The total dose of tramadol consumption in 24 hours was highest in Group A. The number of steps walked postoperatively after 24 hours and level of patient satisfaction was maximum with Group C.

Conclusion: Use of 1mcg.kg^{-1} of dexmedetomidine as adjuvant to 0.2% ropivacaine in ACB after arthroscopic knee surgeries significantly prolongs the duration of postoperative analgesia, reducing the total requirement of rescue analgesic without causing any untoward effects and preserving quadriceps strength aiding in early ambulation and recovery.

Inadequate postoperative analgesia after arthroscopic knee surgeries is known to hamper postoperative ambulation and recovery. Addition of various additives to local anesthetics have been reported to improve analgesic effect of peripheral nerve blocks.

Adductor Canal Block (ACB) has been found to be a relevant option for patients with moderate to severe pain after arthroscopic knee surgery especially when used with lower concentrations of local anesthetics [1].

Dexmedetomidine, a highly selective alpha 2 agonist has been widely used as adjuvant to local anesthetic in order to enhance the postoperative analgesia via peripheral nerve blocks [2].

There are studies reporting the efficacy of dexmedetomidine, when administered perineurally and intravenously but there are no studies comparing two doses of dexmedetomidine administered perineurally in arthroscopic knee surgeries.

The authors declare no conflicts of interest.

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We conducted this study with the primary objective of comparing duration of analgesia provided by two doses of dexmedetomidine in comparison to control group. The secondary objective was to note the total analgesic requirement in 24 hours and side effects if any.

Methods

The study was randomized, double blinded and conducted in our hospital from November 2019 to September 2020 and in accordance with Helsinki declaration of 1970. The consolidated standards of reporting trials CONSORT guidelines are followed.

After getting approval from the institutional ethical committee (Registration No ECR/275/Inst/MH/2013/RR-19), all patients aged 18–65 years with Body Mass Index of 20–35 kg.m-2 and American Society of Anesthesiology physical status 1 and 2 (ASA P1 and P2), scheduled for arthroscopic ligament reconstructions surgeries of knee were enrolled in the study. Patients with refusal for ACB, any known allergy or contraindication to local anesthetic, history of substance abuse, obese patients with Body Mass Index >35kg.m-2, Anesthesiology physical status 3 and 4 (ASA P3 and P4) pregnancy, lactating mothers, long-term analgesic therapy, spinal cord deformities, coagulopathies, local skin infections at the site and patients who required General Anesthesia were excluded from the study.

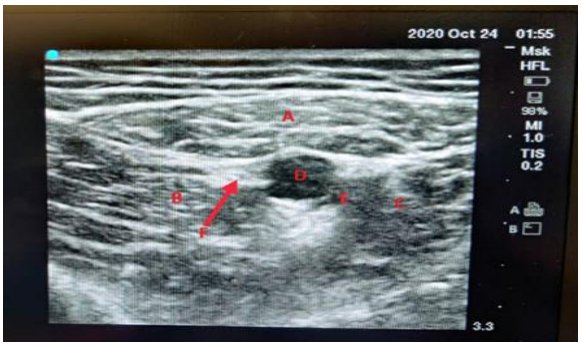
All the patients received Tab. Alprazolam 0.25mg on night before surgery. After overnight fasting, after noting baseline vital parameters and preloading with 10ml/kg of crystalloid over 15-20 minutes all the patients were administered subarachnoid block for the surgery with 3.0 ml (15mg) 0.5% hyperbaric bupivacaine and 25 mcg (0.5 ml) fentanyl. As the expected duration of surgery was about 150±30 mins so we added fentanyl as adjuvant to bupivacaine in Subarachnoid block in all the three groups. We have compared the study groups with control group in order to overcome any bias arising due to addition of fentanyl. No additional analgesic was used intraoperatively. After the completion of surgery (all lasting for 150 to 180 minutes), the patients were given ultrasonography (USG) guided ACB on the operation table itself. The attending anesthesiologist who had an experience of minimum 25 such blocks gave the ACB.

Randomization was done using with The Microsoft Excel®2016 software Mersenne Twister (MT19937) algorithm. The computer generated numbers were allotted to subjects of one of the three group. The numbers were printed and sealed in opaque envelopes. The allocation of the subject to the group was determined once the envelope was opened. The anesthesiologist who opened the envelope prepared the drugs. The anesthesiologist who performed the block was blinded to the group to which patient belonged. 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.

The block solution was made in a 20 ml syringe for each group. Each syringe had 17 ml ropivacaine 0.2%. In addition, in Group A, the syringe contained 3 ml saline; Group B and Group C had 0.50 mcg.kg-1 and 1 mcg.kg-1 dexmedetomidine respectively. The required amount of saline was added in Group B and C syringes to make the volume of 20 ml.

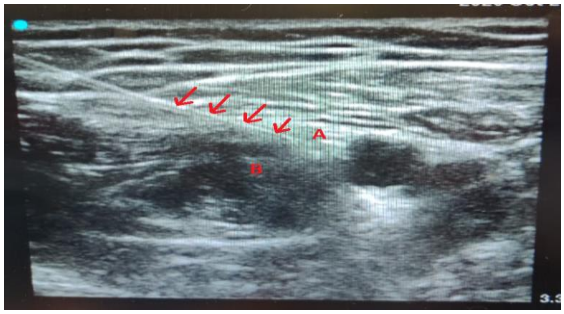
The patient was positioned with operated lower limb slightly abducted at the hip and flexed at the knee. At the level of mid-thigh, an USG guided ACB was performed. The block site was prepped with chlorhexidine. A linear ultrasound probe covered in a sterile dressing was transversely placed to visualize the adductor canal. As shown in (Figure 1), these structures were identified on the ultrasound-boat shaped Sartorius muscle, femoral artery (pulsatile) and femoral vein (compressible by the probe), the latter two also confirmed on Doppler mode. A 23-gauge 10 cm spinal needle was used in plane with the transducer, from lateral to medial, with the needle tip targeted anterolateral to the femoral artery and below the Sartorius.

Figure 1- Ultrasound image showing important landmarks for the adductor canal block. A- Sartorius B-Vastus medialis C- Adductor magnus D- Femoral artery E- Femoral vein F- Saphenous nerve



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 a careful negative aspiration. The spread of the drug between the Sartorius and the femoral artery was seen real time on ultrasound. (Figure 2).

Figure 2- Ultrasound image showing the spread of drug below the sartorius and lateral to femoral vessels. A- Saphenous nerve, B- Spread of drug

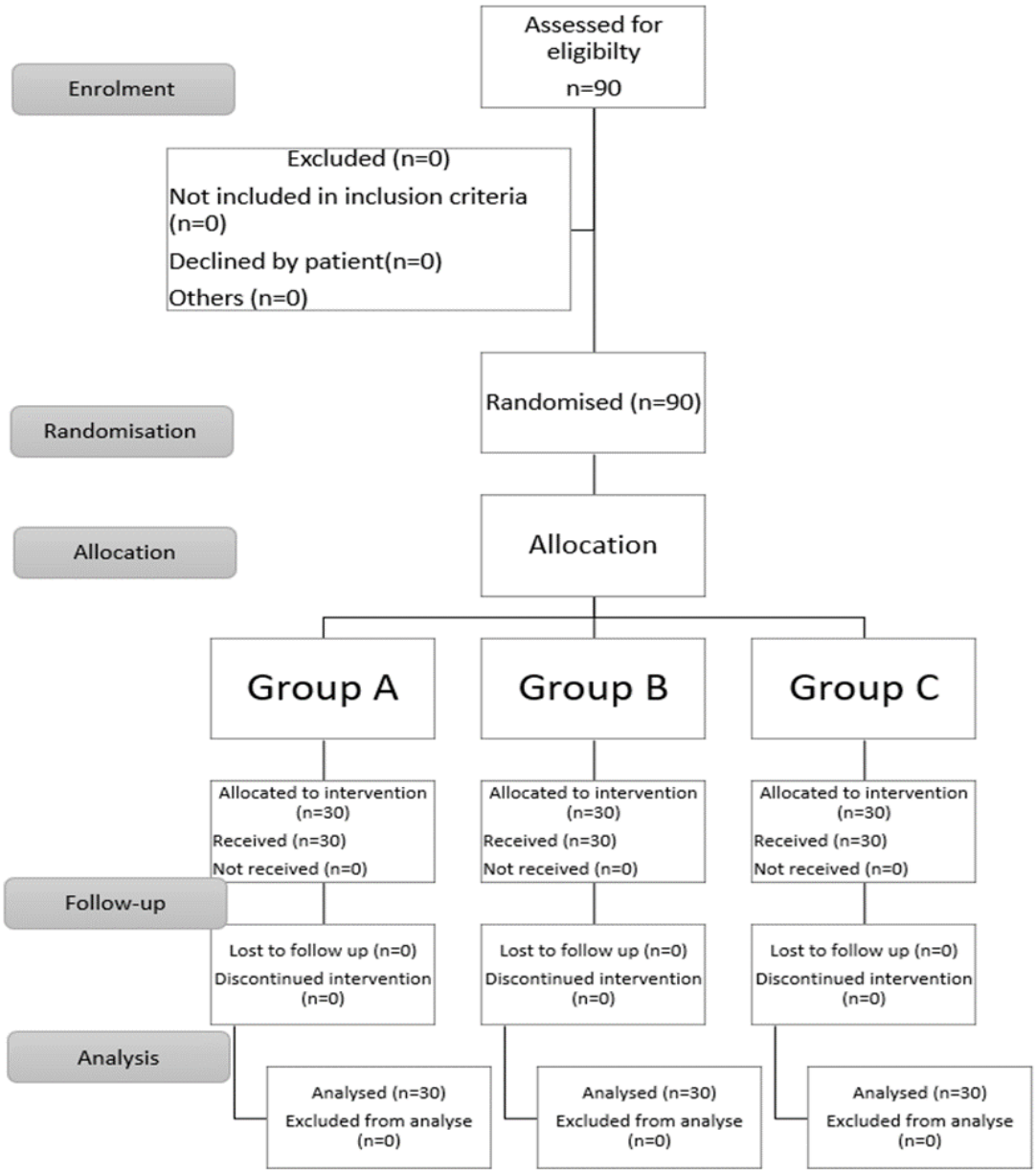


The patients were observed by the anesthesia resident for 60 min in the recovery room. Heart rate (HR), arterial blood pressure (BP) and SpO2 were monitored continuously and noted at 15 min interval for the 1st hour after the block, and then 6-hourly for the next 24 h. Numeric Rating Scale (1–10, 1 being the least and 10 being the worst pain described by the patient) was used to assess pain at 6, 12, 18 and 24 h during the post-operative period. If the patient complained of pain and demanded relief, IV tramadol 1mg/kg was administered. This was considered as the end point of the study. Since the study was terminated at this point the bias due to sedation caused by tramadol was also ruled out as no sedation score was noted after this point. Available vials are either 1ml or 2ml containing tramadol of 50mg/cc concentration. Ondansetron 4 mg was added intravenously if tramadol was used. Time to first rescue analgesia and the total tramadol consumption in 24 h were noted.

The ward nurse collected the data in the post-operative period such as HR, BP and SpO2. Bradycardia and hypotension were defined as 20% decreases from the baseline HR and mean arterial pressure and were treated with atropine and IV fluids, respectively. Sedation was assessed by Ramsay sedation score:

1-Anxious or restless or both; 2- cooperative, orientated and tranquil; 3- Responding to commands; 4- brisk response to commands only; 5- sluggish response to light glabellar tap or loud auditory stimulus; 6- no response to light glabellar tap or loud auditory stimulus.

Figure 3- Consort Diagram



Any adverse event such as nausea, vomiting, shivering, giddiness, local pain, paresthesia, or signs of local anesthetic systemic toxicity were noted. A physiotherapist assessed quadriceps motor strength by straight leg raise on a 0–5 scale pre-operatively and then at 24 h after the block as per the Medical Research Council Scale [3] (0 = no voluntary contraction possible, 1 = muscle flicker, but no movement of limb, 2 = active movement only with gravity eliminated, 3 = movement against gravity but without resistance, 4 = movement possible against some resistance and 5 = normal motor strength against resistance). The patients were assisted to ambulate with support by the physiotherapist when motor strength was ≥ 2 at 24 h. The ward nurse noted the time of ambulation and the number of steps that the patient could walk. She also noted the patient satisfaction score at 72 h postoperatively;

1- Not satisfied,
2-Satisfied
3- better than expected.

Here the patients were also asked about any paresthesia, numbness or pain in the thigh. Both the nurse and the physiotherapist were blinded to the study groups.

The primary outcome of the study was the duration of analgesia. The secondary outcomes included total 24 h opioid consumption, success of early ambulation, level of patient satisfaction and any adverse effects following the study intervention.

The sample size of 28 subjects per group was calculated keeping the power of 80% with confidence interval of 95% and alpha error of 0.05 using "Primer of Biostatistics" software 6.0 (by Stanton A Glantz, 2005 McGraw-Hill)8. However, we enrolled 90 cases to cover for any dropouts, Consort Diagram (Figure 3).

Analysis of the statistical data obtained from study was carried out by statistical data obtained from study was carried out by Statistical Package for the Social Science software version 21 (SPSS). Baseline difference among three groups was analyzed by univariate analysis of variance (ANOVA) and if the ANOVA test was significant, Bonferroni test was applied for calculating the difference between the groups for the duration of analgesia, total dose of tramadol consumption and number of steps walked after 24 hrs. The difference between the Ramsay sedation score was calculated using the chi-square test and the satisfaction score was represented as the percentage of people satisfied in each group.

Results

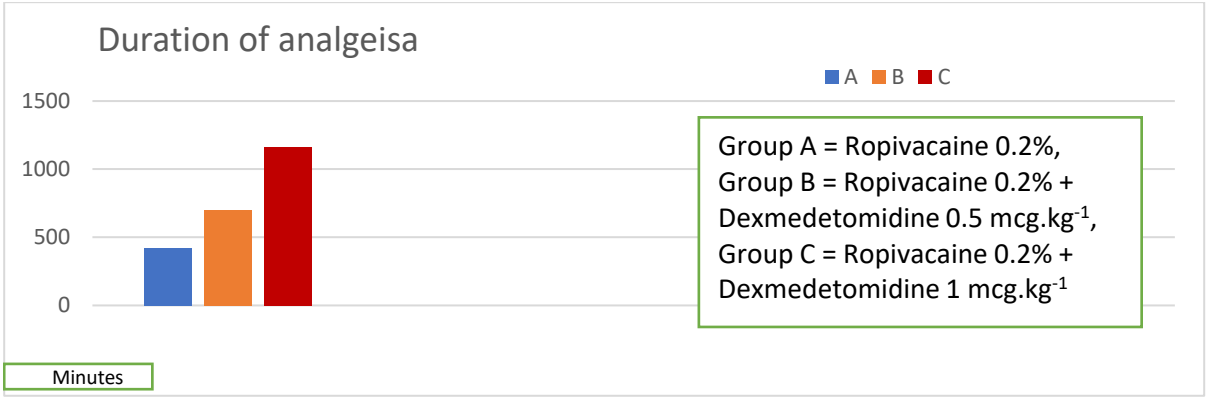
In our study we randomized 90 patients and allotted them into three groups of 30 in each group. We calculated the Demographic characteristics between the three groups using ANOVA test and found it to be statistically non-significant (p 0.932573) (Table1).

Table 1- Demographic Table Group A = Ropivacaine 0.2%, Group B = Ropivacaine 0.2% + Dexmedetomidine 0.5 mcg.kg^{-1}, Group C = Ropivacaine 0.2% + Dexmedetomidine 1 mcg.kg^{-1} (NS- Nonsignificant, p >0.05)

	Group A n=30	Group B n=30	Group C n=30	P value
Age(years)	38.2±8	34.6±	32	P>0.05
ASA (I/II)	20/10	23/7	28/2	P>0.05
BMI (kg.m-2)	26.1	28.3	25.9	P> 0.05
Duration of Surgery (minutes)	150±30	150±30	150±30	P>0.05

The duration of analgesia was found highest in Group C (1166 ±200mins) when compared to Group A (420±100mins) and Group B (702±150mins) (Figure 4), analyzed as statistically significant between A and B (p 0.00516), A and C (p 0.00001) and B and C (p 0.00007) using Bonferroni test.

Figure 4- Duration of Analgesia Group A = Ropivacaine 0.2%, Group B = Ropivacaine 0.2% + Dexmedetomidine 0.5 mcg.kg^{-1}, Group C = Ropivacaine 0.2% + Dexmedetomidine 1 mcg.kg^{-1}



Ramsay Sedation Score calculated using chi-square test was statistically non-significant with the p 0.115 stating no significant difference among the three groups (Table 2).

Table 2- Ramsay sedation score Group A = Ropivacaine 0.2%, Group B = Ropivacaine 0.2% + Dexmedetomidine 0.5 mcg.kg^{-1}, Group C = Ropivacaine 0.2% + Dexmedetomidine 1 mcg.kg^{-1}

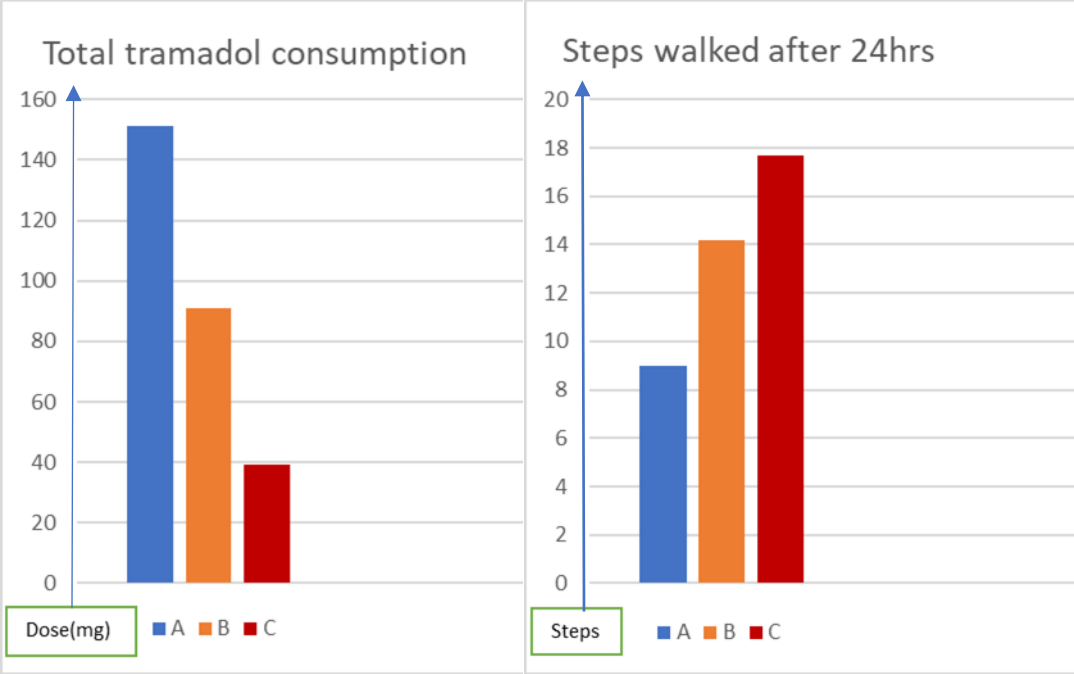
Ramsay sedation score	Group A (number of patients)	Group B (number of patients)	Group C (number of patients)
6	0	0	0
5	0	0	0
4	0	0	0
3	0	1	1
2	23	24	27
1	7	5	2

The total dose of tramadol consumption during 24hours in each group was comparable with significant difference between group A and B (p 0.01438), between group A and C (p 0.00502) and between B and C (p 0.00825).

Number of steps walked after 24 hours were calculated and showed statistically significant difference between group A and B (p 0.00010), between A and C (p 0.0000) and also between B and C (p 0.00030).

The average dose of tramadol consumption in 24 hours, number of steps walked after 24 hours and satisfaction score is shown in the (Figure 5).

Figure 5- Average of total dose of tramadol consumption and steps walked. Group A = Ropivacaine 0.2%, Group B= Ropivacaine 0.2% + Dexmedetomidine 0.5 mcg.kg^{-1}, Group C =Ropivacaine 0.2% + Dexmedetomidine 1mcg.kg^{-1}



33% of patients in Group A were not satisfied (score 1) while 66% were satisfied with score 2. While 73% in Group B were more satisfied than expected with score of 3 and in Group C 93% patients had a satisfaction score of 3.

Discussion

Our study shows a dose dependent improvement in duration of analgesia and reduced requirement of rescue analgesics with incremental doses of dexmedetomidine when used as adjuvant to ropivacaine in Adductor Canal Block (ACB) without significant increase in the incidence of side effects.

ACB is epochal for its motor sparing property, and provides analgesia to the anteromedial aspect of the thigh [4]. The property of sensory blockade is due to the saphenous nerve (pure sensory nerve) traversing the canal which can be blocked at the level of mid-thigh [4]. A similar approach was used in our study while performing ACB. We have used Ultrasound guided

(USG) technique [5-6] for administering ACB as it is now the gold standard for regional anesthesia.

Postoperative analgesia by ACB facilitates early ambulation and recovery while preserving quadriceps strength [4]. It has been studied for postoperative analgesia after arthroscopic knee surgeries [5], meniscectomies [6], anterior cruciate ligament surgeries [7] and TKA (total knee arthroplasty) [8].

Ropivacaine is an evolving local anesthetic (LA) with predominant sensory blocking action. It may be due to its less lipophilic nature and hence less likelihood of penetrating large myelinated nerve fibers [9].

Perlas A et al conducted a study with 100 mg ropivacaine in ACB along with local infiltration analgesia (300 mg ropivacaine) for unilateral TKA. Their results suggested better analgesia and patient could walk greater distance as compared to the continuous femoral nerve block. The discharge rate was also better in the patients who received ACB with ropivacaine [10].

Addition of adjuvant to local anesthetic in order to prolong the duration of postoperative analgesia is now a usual practice. Several agents as dexamethasone, clonidine, fentanyl, dexmedetomidine have been used in varied doses for this purpose. We chose dexmedetomidine as it is highly selective alpha 2 agonist. It has sedative, analgesic and sympatholytic effects that blunt many of the cardiovascular responses seen during the perioperative period [11]. Due to its effects on sedation, hemodynamic and analgesia, finding the optimum dose is yet a question. Earlier studies have been conducted with a variety of doses of dexmedetomidine in association with LA but none in ACB for Arthroscopic knee surgeries.

Various routes of administration of adjuvants have also been studied like perineurally, intravenous etc. Perineurally administered dexmedetomidine causes vasoconstriction, inhibition of C-fibers discharge and causes a reduction in the release of inflammatory mediators [12]. Intravenous administration causes enhancement in postoperative analgesia by central actions [13] and also potentiates the occurrence of side effects like hypotension and bradycardia [11-12] Dexmedetomidine when given perineurally is found to be safe in terms of systemic side effects even with higher doses avoiding the effects of hypotension, bradycardia, sedation etc [14].

Goyal et al conducted a study in cases of bilateral Total Knee Replacement (TKR) and found better analgesic results, early ambulation and showed that the addition of dexmedetomidine to ropivacaine in ACB up to 1mcg.kg^{-1} does not affect the HR, blood pressure and SpO2 [15]. Their results are consistent with those of others.

Kathuria et al. found that addition of dexmedetomidine (50 mcg) to 30 ml ropivacaine 0.5% in ultrasound-guided (SBPB) supraclavicular brachial plexus block resulted in a quick onset and prolonged duration of blockade and analgesia [16].

In contrast, Oritz-Gomez et al. could not find any significant difference between pain scores in TKR patients in ACB group with and without dexmedetomidine [17]. However the pain pathways are different (sciatic and femoral nerves) for TKR and ACL repairs (saphenous nerve). Hence the results of this study should be considered in a different perspective.

While Memary et al studied the effect of perineurally administered dexmedetomidine in shaft femur fracture patients and found increased consumption of rescue analgesic at 24 hours [12].

In our study we could derive a linear relationship between the dose of dexmedetomidine and duration of analgesia.

In earlier conducted studies combining dexmedetomidine with LA produced inconsistent results which may be due to lower doses of dexmedetomidine used [18]. Abdulatif et al found a dose dependent opioid sparing effect with perineurally administered dexmedetomidine [14].

Packiasabapathy et al studied perineurally given dexmedetomidine, 1 versus 2 mcg.kg^{-1} as adjuvant to LA (0.25% bupivacaine 20mL) in FNB and concluded that 1 mcg.kg^{-1} did not significantly reduce postoperative morphine consumption at 24hours, but 2 mcg.kg^{-1} produced significant reduction in morphine consumption [18].

We also studied the total dose of rescue analgesics demanded by the patients in first 24 hours and the results of our study suggest that the total dose of rescue analgesic was minimal in that group of patients who received dexmedetomidine 1mcg.kg^{-1}. This finding has been supported by earlier studies [19] while some studies who do not affirm with this result have a difference of opinion [18].

Another parameter which was considered was the number of steps walked after 24 hours and the motor strength of quadriceps muscles as assessed by a physiotherapist. Our study findings confirm that even the higher dose of dexmedetomidine preserves motor strength of quadriceps while allowing the patients to be pain free and walk for comparatively longer distances early (after 24 hours) in the postoperative period. Goyal et al had similar results in post SBTKR patients with 0.25 mcg.kg^{-1} and 0.50 mcg.kg^{-1} of dexmedetomidine [15].

Thapa et al found that 0.5 mcg.kg-1 of dexmedetomidine preserved quadriceps strength and allowed complete range of movements at 24 hours postoperatively [7]. They used 0.5% ropivacaine with 0.5 mcg.kg^{-1} of dexmedetomidine. In our study we have used lower concentration of (0.2%) while increasing the dose of dexmedetomidine which might be the reason for better analgesia without motor deficit.

Sedation scores assessed in post-operative ward showed mild drowsiness in subjects but were arousable and alert on waking up. This finding is consistent with characteristics of dexmedetomidine [14] also earlier studies suggest more sedative effect with I.V dexmedetomidine due to central action [13]. Intravenous tramadol also affect the sedation score, we used tramadol as an rescue analgesia when the action of the ropivacaine with dexmedetomidine was weaned off. After that we didn't assess the sedation score.

None of the patients complained of nausea or vomiting. No events of hypotension or bradycardia were noted in the postoperative period. Patients with dexmedetomidine 1mcg.kg^{-1} as adjuvants were more satisfied regarding pain control and ease during physiotherapy as represented in satisfaction score and this may be attributed to lower concentration of LA with higher dose of dexmedetomidine providing pure sensory effect with complete control of lower limb.

Authors admit certain limitations of the study: Firstly, more doses of dexmedetomidine should have been studied to look if higher doses can be used with low concentrations of LA. Secondly ASA grade III and IV patients need to be studied to assess the impact of higher doses of dexmedetomidine on hemodynamic parameters. This can be considered as selection bias.

Conclusion

Dexmedetomidine in a dose of 1 mcg.kg^{-1} when administered with 0.2% ropivacaine in ACB significantly prolongs the duration of postoperative analgesia after ligament reconstructions surgeries of knee. Higher dose of dexmedetomidine does not increase the incidence of adverse effects, meanwhile preserving the quadriceps strength, reducing the total requirement of rescue analgesic and aiding in early ambulation.

Abbrevations

Adductor Canal Block (ACB), Dexmedetomidine (DEX), Heart Rate (HR), Blood Pressure (BP), milligram-(mg), millilitre- (ml), centimetre- (cm), microgram- (mcg), Total Knee Replacement- (TKR), Hour- (hr), minute- (min), Femoral Nerve Block – (FNB), kilogram- (kg)

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