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SCIENTIFIC ARTICLE

Comparison of adductor canal block for analgesia in arthroscopic surgery with ropivacaine alone and ropivacaine and clonidine



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KEYWORDS

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Postoperative
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Clonidine

Abstract

Background and objectives: Inadequate pain relief after anterior cruciate ligament reconstruction affects mobility leading to development of adhesions, weakened ligament insertion and muscle atrophy. Adductor canal block for postoperative analgesia preserves quadriceps strength. The present study was conducted to compare pain free period in patients undergoing arthroscopic anterior cruciate ligament reconstruction, receiving ultrasound-guided adductor canal block with ropivacaine alone and ropivacaine with clonidine.

Methods: A prospective randomized double blinded study was conducted including sixty-three adult, ASA class I, II patients undergoing anterior cruciate ligament reconstruction. They were randomized into three groups: Group S – control group received adductor canal block with 30 mL saline, Group R – ropivacaine group received adductor canal block with 30 mL of 0.375% ropivacaine and Group RC – clonidine group received adductor canal block with 30 mL of 0.375% ropivacaine with clonidine 1 $\mu\text{g}\cdot\text{kg}^{-1}$. The primary aim was to compare the pain free period in patients receiving adductor canal block with ropivacaine alone or ropivacaine with clonidine. The secondary outcomes were pain score at rest and movement, total analgesic requirement, sedation score and postoperative nausea and vomiting.

Results: The mean pain free periods were 20 min, 384.76 min and 558.09 min for Group S, Group R and Group RC, respectively and this difference was statistically significant ($p < 0.001$). There was no significant difference between Group R and Group RC in terms of pain scores at rest and movement and total analgesic requirement.

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Conclusion: Addition of clonidine to ropivacaine in USG guided adductor canal block led to significant prolongation of pain free period though pain score at rest and movement, and rescue analgesic requirement, did not differ.

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PALAVRAS-CHAVE

Bloqueio do canal adutor;
Reconstrução do ligamento cruzado anterior;
Analgesia pós-operatória;
Clonidina

Comparação do bloqueio do canal adutor para analgesia em cirurgia artroscópica com ropivacaína isolada e ropivacaína + clonidina

Resumo

Justificativa e objetivos: O alívio inadequado da dor após a reconstrução do ligamento cruzado anterior afeta a mobilidade, leva ao desenvolvimento de aderências, inserção do ligamento enfraquecido e atrofia muscular. O bloqueio do canal adutor para analgesia pós-operatória preserva a força do quadríceps. O presente estudo foi feito para comparar o período sem dor em pacientes de reconstrução artroscópica do ligamento cruzado anterior, submetidos ao bloqueio do canal adutor guiado por ultrassom com ropivacaína isolada e ropivacaína + clonidina.

Métodos: Um estudo prospectivo, randômico e duplo-cego foi conduzido com 63 pacientes adultos, estado físico ASA I-II, submetidos à reconstrução do ligamento cruzado anterior. Os pacientes foram randomizados em três grupos: Grupo S, que recebeu bloqueio do canal adutor com 30 mL de solução salina para controle; Grupo R, que recebeu bloqueio do canal adutor com 30 mL de ropivacaína a 0,375%; Grupo RC, que recebeu bloqueio do canal adutor com 30 mL de ropivacaína a 0,375% e 1 $\mu\text{g}\cdot\text{kg}^{-1}$ de clonidina. O desfecho primário do estudo foi comparar o período sem dor nos pacientes que receberam bloqueio do canal adutor com ropivacaína isolada ou ropivacaína + clonidina. Os desfechos secundários foram escores de dor em repouso e movimento, necessidade total de analgésicos, escore de sedação, além de náusea e vômito no pós-operatório.

Resultados: Os períodos médios sem dor foram 20 min, 384,76 min e 558,09 min para os grupos S, R e RC, respectivamente, e essa diferença foi estatisticamente significativa ($p < 0,001$). Não houve diferença significativa entre os grupos R e RC em termos de escores de dor em repouso e movimento e a necessidade total de analgésicos.

Conclusão: A adição de clonidina à ropivacaína em bloqueio do canal adutor guiado por ultrassom levou a um prolongamento significativo do período sem dor, embora os escores de dor em repouso e movimento, e a necessidade de analgésico de resgate, não tenham diferido.

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Introduction

Acute postoperative pain after anterior cruciate ligament (ACL) reconstruction can last for up to 48 h postoperatively and result in poor outcome due to delayed recovery, prolonged hospital stay, inability to participate in rehabilitation programs and greater use of health-care resources.¹ Inadequate pain relief in postoperative period leads to poor mobility thereby resulting in development of adhesions, weakened ligament insertion and muscle atrophy.² To address this issue of severe postoperative pain, several authors have suggested femoro-sciatic and obturator nerve blocks along with use of adjuvants to local anesthetic drugs through various routes like intrathecal or intra articular.³⁻⁵ The current understanding of the anatomy describing the innervations of the knee joint have led to use of Adductor Canal Block (ACB) for post operative analgesia following knee joint surgeries.⁶ With this background, the present randomized controlled trial was conducted to compare the pain free period in patients undergoing arthroscopic

ACL reconstruction surgery, receiving USG guided ACB with ropivacaine alone and ropivacaine with clonidine.

Methods

After approval from institute ethical committee (MS/1744/MD/8453) and written informed consent from participants, a prospective randomized double blinded study was conducted including sixty-three ASA Class I and II patients of either sex, in the age group of 18–50 years, undergoing arthroscopic ACL reconstruction. All the patients were admitted in evening prior to surgery and stayed in hospital for 24h postoperatively. Patients with local infections of skin, anatomical deformities, coagulation disorders, history of allergy to local anesthetic drugs, body mass index more than 30 and unwilling to participate were excluded. The primary aim of the study was to compare the pain free period in patients undergoing arthroscopic ACL reconstruction surgery, receiving USG

guided ACB, receiving ropivacaine alone or ropivacaine with clonidine. The secondary outcomes measured were pain score at rest and at movement, the total analgesic requirement, sedation score and Postoperative Nausea and Vomiting (PONV). All the patients enrolled for this study were randomized into three groups; Group S – Control Group, in which patients received ACB with 30 mL saline, Group R – Ropivacaine Group, in which patients received ACB with 30 mL of 0.375% ropivacaine and Group RC – Clonidine Group, in which patients received ACB with 30 mL of 0.375% ropivacaine with clonidine $1 \mu\text{g}\cdot\text{kg}^{-1}$ added to this volume. Randomization was done by computer generated randomization number using block randomization design with a block size of seven and the random numbers were enclosed in a sealed opaque envelop which was opened by investigator inside the operation theater. Observer who collected the post-operative data was blinded to the group.

The patients were educated about the 11 point Numerical Rating Score (NRS) where 0 is no pain and 10 is worst imaginable pain during pre-anesthetic assessment a day prior to the surgery. Premedication of oral alprazolam 0.5 mg was prescribed on the night prior and on the day of the surgery. Inside operating room, intravenous line was secured and normal saline infusion was started. Standard ASA monitoring (electrocardiogram, non invasive blood pressure and pulse oximetry) was applied. Injection morphine $0.1 \text{ mg}\cdot\text{kg}^{-1}$, propofol $2\text{--}3 \text{ mg}\cdot\text{kg}^{-1}$ was used for induction of anesthesia and tracheal intubation was facilitated by vecuronium $0.1 \text{ mg}\cdot\text{kg}^{-1}$, intravenously (i.v.).

All the patients were mechanically ventilated in volume-controlled mode with tidal volume $8\text{--}10 \text{ mL}\cdot\text{kg}^{-1}$ and respiratory frequency of 10–12 min to maintain EtCO_2 in the range of 35 and 40 mm of Hg. Anesthesia was maintained with isoflurane in a 60:40 mixture of nitrous oxide with oxygen and vecuronium $0.02 \text{ mg}\cdot\text{kg}^{-1}$ when required.

Heart rate, Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and oxygen saturation were recorded at an interval of 2.5 min for 10 min after administration of General Anesthesia (GA). Thereafter, these were recorded at 10 min interval till the end of the surgery. After completion of the surgery and before reversal, adductor canal block was performed under USG guidance. All aseptic precautions were taken and a high-frequency linear ultrasound transducer probe (SonoSite, micromaxx with transducer of L38e/10–5 MHz) was placed transversely to the longitudinal axis of the extremity at the mid thigh, approximately 10–15 cm proximal and 3–4 cm medial to the midpoint of the patella. The femoral artery was identified with certainty by power Doppler. This confirmed the identity of the overlying sartorius muscle as at this position, saphenous nerve is placed lateral to the artery. A 23G spinal needle was inserted into the adductor canal lateral to the femoral artery (in-plane approach) and drug was injected according to the groups mentioned above.

At the end of the surgery patient was given ondansetron 4 mg i.v. for prophylaxis of postoperative nausea and vomiting. Injection neostigmine $0.05 \text{ mg}\cdot\text{kg}^{-1}$ and $0.01 \text{ mg}\cdot\text{kg}^{-1}$ of glycopyrolate were given i.v. for residual neuromuscular blockade and trachea was extubated once the respiration was spontaneous, regular and adequate and patient responded to verbal commands.

After surgery, the patients were shifted to Post Anesthesia Care Unit (PACU). Each patient was observed for 24 h at 0, 1, 2, 4, 8, 12, 18 and 24 h interval. The time zero was defined as the time at arrival in PACU and the patient was observed for pain score – at rest and at movement of the leg (straight leg raising) using 11 point NRS. Rescue analgesic requirement was also noted. When NRS score was more than 3, injection tramadol 100 mg i.v. was administered as first rescue analgesic. If NRS remained more than 3, diclofenac 75 mg i.v. in 100 mL saline was given as second rescue analgesic and if NRS still remained more than 3, 1 g paracetamol was used as the third rescue analgesic. Maximum dose of tramadol administered was $400 \text{ mg}\cdot\text{day}^{-1}$. At the end of 24 h study period, total rescue analgesic requirement was recorded. Pain free period was defined as time interval between test drug administration up to first rescue analgesic administration in minutes. Sedation was assessed using the following Modified Observer's Assessment of Alertness/Sedation Score (Table 1).

PONV was assessed as mild (nausea with no vomiting), moderate (nausea and vomiting, subsiding with anti-emetic) or severe (vomiting, not subsiding even with anti-emetic).

Sample size was calculated based on pilot data of arthroscopic surgery performed without ACB block. The mean pain free period was 60 min with standard deviation of 25 min. To increase the pain free period by at least 50% with alpha of 0.05 and beta error of 0.95, the calculated sample size for each group was 19. In order to take care of dropouts, 21 patients were recruited in each group.

The measurable or parametric data like BP, HR, and rescue analgesic requirement was first tested for normality using Kolmogorov Smirnov test. Normal data was analyzed by ANOVA followed by Tukey HSD test. Non normal data was compared and analyzed by Kruskal–Wallis ANOVA test followed by Mann–Whitney *U* test. Classification data such as mild, moderate and severe was analyzed by Chi-square test. Bonferroni correction was used to correct for multiple testing at different time points. Time for first rescue analgesic medication was analyzed using survival analysis and represented by Kaplan–Meier survival curves. A *p*-value of less than 0.05 was considered significant.

Table 1 Patient sedation score.

Response	Score level
Responds readily to name spoken in normal tone	5 (alert)
Lethargic response to name spoken in normal tone	4
Responds only after name is called loudly or repeatedly	3
Responds only after mild prodding or shaking	2
Does not respond to mild prodding or shaking	1
Does not respond to noxious stimulation	0

Data obtained using Modified Observer's Assessment of Alertness/Sedation Score.

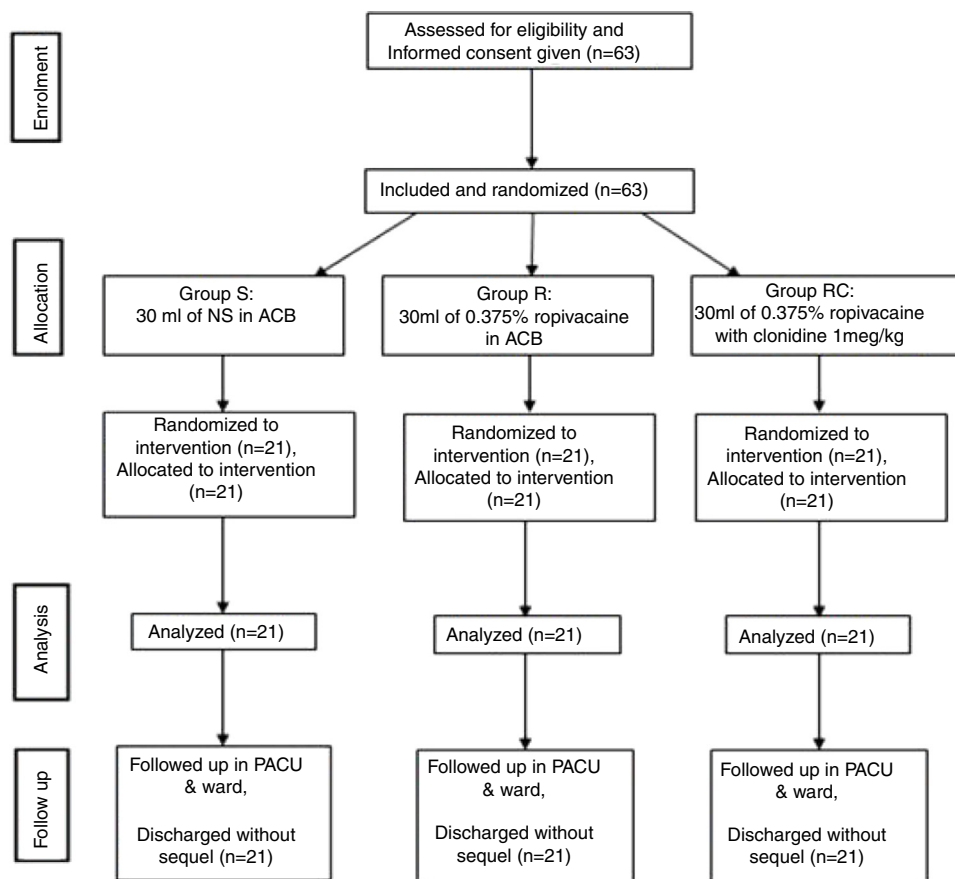


Figure 1 Consort.

Results

A total of 63 patients were include, twenty-one in each group (Fig. 1). The patients in all three groups were comparable in terms of age, weight, duration of anesthesia and duration of surgery (Table 2). All the patients participated in the study were ASA 1 physical status. Only 3 female patients participated in the study in which one was in Group S and other two were in Group RC.

Pain free period was assessed using Kaplan Meier's survival analysis. Fourteen patients in Group S required rescue analgesia in the immediate post-operative period and 7 patients required after 60 min, thus the maximum pain free period was 60 min. In Group R and RC, the maximum pain free period was 750 min and 1080 min, respectively (Fig. 2) The mean pain free periods were 20 min, 384.76 min and 558.09 min for Group S, Group R and Group RC, respectively and this difference was statistically significant ($p < 0.001$).

NRS at rest was significantly lower in Group R and Group RC in 2nd hours compared to Group S. At 4th hour, all the three groups had similar pain scores. Then at 8th hour pain scores were significantly lower in Group R and Group RC. However, there was no significant difference between Group R and Group RC. The pain scores were similar in all the three groups after 12 h (Table 3).

NRS on movement was significantly higher in the Group S compared to the other two groups in 2nd hours. At 4th hour

and 8th hour, patient in Group RC had reduced pain scores compared to Group S, but this difference was not observed in Group R. No significant difference was observed between the groups after 12 h (Table 4).

For convenience during analysis 100 mg tramadol was taken equivalent to 75 mg diclofenac or 1 g PCM which in turn were considered as 1 unit. Usage of rescue analgesia was significantly more in Group S during 2nd hours and also at 24th hour. Total analgesic requirement was lower in Group R and Group RC compared to Group S. There was more than 50% reduction in the requirement of the rescue analgesia in Group R and Group RC. There was no significant difference between Group R and Group RC regarding requirement of rescue analgesia over the period of observation (Fig. 3).

The intraoperative hemodynamic parameters were comparable between the groups. However, in post-operative period, HR, SBP and DBP were significantly higher in Group S as compared to Group R and Group RC. There was no significant difference between Group R and Group RC. HR was considerably lower in Group R and Group RC up to 8 h in the post-operative period. SBP was lower in Group R and Group RC than Group S during 4th hours whereas DBP was significantly lower only during 2nd hours.

Sedation scores were comparable between all the groups at all the times during the observation and no significant difference was observed between the groups. Ten patients in Group S presented with mild to moderate nausea at few

Table 2 Demographic parameters.

	Group S (n=21)	Group R (n=21)	Group RC (n=21)	p-value
Age (yrs)	27.5 ± 5.4	28.5 ± 6.8	27.2 ± 5.8	0.56
Weight (kg)	73.7 ± 7.0	73.5 ± 7.6	72.8 ± 10.1	0.84
Duration of anesthesia (min)	126 ± 8.2	119 ± 10.6	122 ± 12.2	0.34
Duration of surgery (min)	68 ± 10.3	72 ± 8.2	69 ± 9.7	0.47

Data presented in mean ± SD.

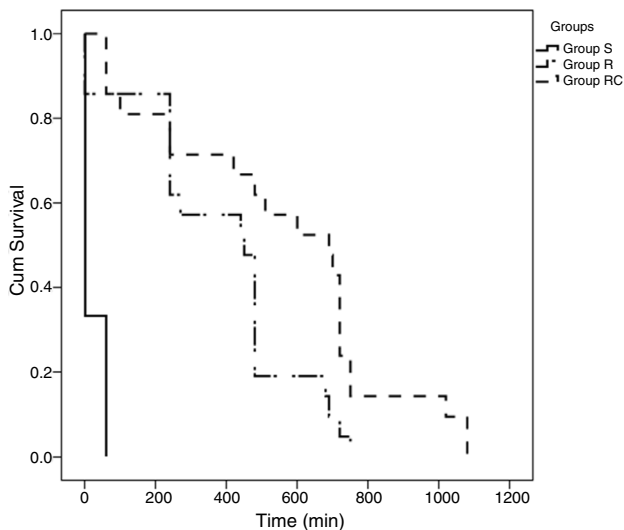


Figure 2 Kaplan–Meier survival graph depicting the pain free period among the three groups. Group 1 is saline group, Group 2 is ropivacaine and Group 3 is ropivacaine with clonidine. All patients in Group S required analgesia within 1hr. Group R had a maximum pain free period of 750min and Group RC had a maximum pain free period of 1080min.

time intervals during the observation. Three patients in the Group R and two patients in the Group RC had severe nausea and episode of vomiting only at few time intervals during observation and these differences were not statistically significant.

Discussion

In the present study, the use of USG guided ACB with 30 mL of 0.375% ropivacaine with clonidine 1 mcg.kg⁻¹ in patients undergoing ACL repair led to prolongation of pain free period and decreased pain scores. The addition of clonidine to ropivacaine prolonged the pain free period by almost 3 h, though the total requirement of rescue analgesic did not differ significantly with the use of adjuvant.

Similar to the results of our study, Akkaya and colleagues reported low pain scores in patients receiving trans-sartorial saphenous nerve block with 0.5% bupivacaine post meniscotomy as compared to the placebo group for a period of 24h. Pain scores at rest, activity and during weight bearing were significantly lower in the local anesthetic study group.⁷ Similarly, Lundbald and coworkers studied the effectiveness of Infrapatellar Nerve Block (IPNB) using 0.5% levo-bupivacaine in ACL reconstruction surgeries. Their results demonstrated a reduction in the pain scores at rest from 16 to 24h in the IPNB group when compared to the placebo group. However, no significant differences in post-operative pain scores were evident on activity.⁸ Another randomized controlled trial by Hanson et al. also showed that ACB significantly decreases postoperative pain and consumption of opioids in 24th postoperative hours following arthroscopic surgery.⁹

The duration of analgesia with ACB in the present study was confined to 8th hours which could be explained by use of lower concentration of ropivacaine (0.375%). Ropivacaine has a slightly shorter duration of action compared to bupivacaine and levo-bupivacaine used by the authors of previous study.^{7,8} Also, in our study, the nerve was not identified and

Table 3 NRS at rest.

Time (h)	NRS at rest			p-value	Mann–Whitney U		
	Group S (n=21)	Group R (n=21)	Group RC (n=21)		S-R	S-RC	R-RC
0	4.00 (3–4)	1.00 (0–1.5)	1.00 (0–1)	0.000 ^a	0.000 ^a	0.000 ^a	0.904
1	4.00 (3–5)	1.00 (0–1.5)	1.00 (0–2)	0.000 ^a	0.000 ^a	0.000 ^a	0.862
2	3.00 (2–3)	1.00 (1–2)	1.00 (0.5–2)	0.000 ^a	0.000 ^a	0.000 ^a	0.936
4	2.00 (1–3)	2.00 (1–2)	2.00 (1–2)	0.169	0.120	0.095	0.826
8	3.00 (2–4)	2.00 (1–2.5)	2.00 (1–3)	0.011 ^a	0.008 ^a	0.013 ^a	0.758
12	2.00 (2–3)	2.00 (2–3)	2.00 (2–3)	0.375	0.172	0.678	0.349
18	3.00 (2–3)	2.00 (2–3)	2.00 (2–3)	0.204	0.112	0.138	0.957
24	2.00 (2–3)	2.00 (2–2)	2.00 (2–2)	0.146	0.070	0.462	0.162

^a Data presented as median and interquartile range. p-value <0.05 considered significant.

Table 4 NRS at movement.

Time (h)	NRS on movement			p-value	Mann-Whitney U		
	Group S (n=21)	Group R (n=21)	Group RC (n=21)		S-R	S-RC	R-RC
1	6.00 (5–6)	1.00 (0.5–2)	1.00 (0–2)	0.000 ^a	0.000 ^a	0.000 ^a	0.667
2	4.00 (3–5)	2.00 (1–2)	2.00 (1–3)	0.000 ^a	0.000 ^a	0.000 ^a	0.592
4	3.00 (3–4)	3.00 (2–4)	2.00 (2–3)	0.034 ^a	0.181	0.008 ^a	0.222
8	5.00 (3–5)	4.00 (3–4.5)	3.00 (2.5–4)	0.035 ^a	0.093	0.011 ^a	0.398
12	4.00 (3–5)	3.00 (3–4.5)	4.00 (3–4.5)	0.503	0.249	0.653	0.462
18	3.00 (2–3)	2.00 (2–3)	2.00 (2–3)	0.204	0.218	0.018	0.170
24	4.00 (3–4)	3.00 (3–4)	4.00 (3–4)	0.409	0.206	0.813	0.317

^a Data presented as median and interquartile range. p-value <0.05 considered significant.

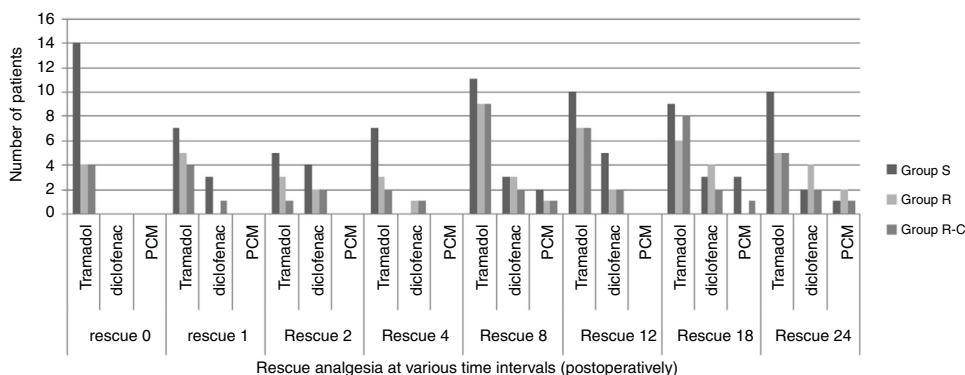


Figure 3 Rescue analgesic requirements in three groups. Bar chart depicting the number of patients requiring rescue analgesia among the three groups. Significant difference is seen in first 2 h and at 24 h.

block was just given in the adductor canal. The difference in surgical procedure could also be a factor in the different results of the studies.

Addition of clonidine to ropivacaine in ACB increased the pain free interval by nearly 3 h (174 min) when compared to ropivacaine alone. Similar finding was reported by Popping and coworkers in a meta-analysis of randomized control trials regarding clonidine as an adjuvant to local anesthetics in peripheral nerve and plexus block. They pooled the results of three studies which used clonidine as an adjuvant to ropivacaine and reported that addition of clonidine increased the duration of analgesia by 141 min.¹⁰

Our study demonstrates hemodynamic parameters i.e. HR, SBP and DBP were significantly lower in Group R and Group RC compared to Group S during early post-operative period. These differences in the hemodynamic parameters in the early post-operative period may indicate that patients in study groups experienced less pain and its associated physiological responses when compared to placebo group. Also, no patient in Group R or Group RC had episodes of bradycardia and hypotension during the period of observation.

Hemodynamic variations are also associated with administration of clonidine in PNB. Bernad and Macaire conducted a study on dose-range effects of clonidine added to lidocaine for brachial plexus block. They used a clonidine dose of 30 µg, 90 µg and 300 µg along with lidocaine in brachial plexus block and observed increased incidence of hypotension and bradycardia in patients receiving 300 µg of

clonidine in the PNB. They also reported that two patients could not be discharged on the day of surgery due to severe hypotension for several hours. Incidence of orthostatic hypotension was also increased in patients receiving 300 µg of clonidine.¹¹

Similarly, Adan et al. reported hypotension with the use of 150 µg of clonidine in patients receiving axillary block with lidocaine.¹² Madan et al. also reported increased incidence hypotension and dizziness with the use of 1.5 µg.kg⁻¹ of clonidine in the peribulbar block.¹³ This can have important implications in ambulatory anesthesia such as need for monitoring, difficulty in ambulation and delay in discharge. In our study as we used 1 µg.kg⁻¹ of clonidine as an adjuvant to ropivacaine in ACB, adverse effects associated with clonidine were not observed.

We also noted the occurrence of adverse effects such as sedation and PONV in patients participating in the study. Sedation score did not differ in all the three groups. Clonidine has been associated with increased sedation as systemic absorption can occur when it is administered perineurally. Macarthy et al. in their review article observed that occurrence of adverse effect was dose dependent and few studies demonstrated occurrence of adverse effects with dose of 150 µg.¹⁴ In our study we used clonidine at a dose of 1 µg.kg⁻¹ and never exceeded 150 µg in any of the patients.

Tramadol has been associated with nausea and vomiting, but in our study incidence of PONV did not vary among the groups. Occurrence of PONV is usually low in lower limb surgeries. Most of the patients included in our study were

males and all the patients were induced with propofol and received PONV prophylaxis at the end of surgery. We believe all these factors decreased the risk for the occurrence of PONV and our sample size was not sufficient to identify the difference if it occurred.

The ACB is an almost pure sensory block, with the vastus medialis muscle as the only muscle with potentially affected motor function. In our study, patients were encouraged to perform the motor activity (i.e. lifting of the lower limb) 1 h after the surgery. This implies that the motor block of the quadriceps muscle was nominal. This provides a very important advantage compared with the femoral nerve block as it has been demonstrated that even a very low dose/low volume continuous FNB reduces the strength of the quadriceps muscle by more than 80% in human volunteers.⁸ Jaeger and colleagues have demonstrated improvement in ambulation along with preservation of quadriceps strength with ACB as compared to FNB.¹⁵ Only a reduction of 8% in quadriceps strength from baseline was reported whereas 49% reduction was found following FNB.

Many investigators have focused on the risk of falling associated with peripheral nerve blocks of the lower limbs. Ilfeld et al. reported seven falls in 171 patients receiving a peripheral nerve block involving the femoral nerve. All of these falls occurred in the active treatment group showing a probable causal relationship between peripheral nerve blocks involving the femoral nerve and fall episodes.¹⁶ The quadriceps muscle is essential in mobilization. The ACB spares three out of the four components of the quadriceps muscle such that the risk of falling caused by quadriceps weakness is diminished.

However, a study by Seo et al. concluded that although ACB preserves quadriceps strength and walking ability, it is not superior to FNB in pain management. Also, it is inferior to FNB when the catheter is placed for continuous block as the exact location of catheter cannot be ensured with ACB as compared to FNB.¹⁷

There are certain limitations of our study. First of all, we did not look for the sensory nerve block at the level of the ankle and hence could not accurately determine the duration of the blockade. Secondly, 3 patients in the Group R and 3 patients in the Group RC required rescue analgesia within 60 min. We could not determine whether this finding was due to block failure or ineffectiveness of ACB in these patients. Additionally, the surgical technique involved obtaining the graft from the patellar tendon. So our results may not be applicable in surgeries where graft for reconstruction is taken from the hamstring muscles. Also, the use of ropivacaine at low concentration preferentially blocks the sensory nerves more than motor nerves, the absence of motor block cannot be attributed to ACB alone.

Conclusion

Administration of USG guided ACB using ropivacaine (0.375%) with clonidine (1 mcg.kg⁻¹) led to prolongation of pain free period as compared to use of ropivacaine (0.375%) alone or placebo though the pain score at rest and movement and rescue analgesic requirement did not differ significantly. Also, use of USG guided ACB using ropivacaine with or without

clonidine did not have adverse effect in terms of hemodynamics, sedation or PONV.

Conflicts of interest

The authors declare no conflicts of interest.

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