Original Article

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Postoperative Analgesia with Adductor Canal Block using Ropivacaine, Buprenorphine and Dexamethasone versus Ropivacaine and Dexamethasone in Knee Surgery Patients: A Randomised Controlled Trial

Anaesthesia Section

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ABSTRACT

Introduction: The adductor canal nerve block has become contemporary, safe, highly effective and minimally invasive approach with faster sensory onset and greater success rate, without causing any quadriceps weakness, for postoperative pain management in knee surgery patients. The duration of block can be prolonged with addition of multiple perineural adjuvants, reducing the requirement of continuous catheters and other parenteral or oral analgesics.

Aim: To compare postoperative analgesia provided by addition of Buprenorphine and Dexamethasone to Ropivacaine vs addition of Dexamethasone alone.

Materials and Methods: A randomised controlled double-blind trial was conducted at a tertiary care rural teaching hospital in Gujarat, India. A total of 70 patients aged 18 to 75 years, planned for knee surgeries, were randomised in two groups using web-based program. Group A received 25 mL of 0.25% ropivacaine, 150 µg Buprenorphine, and 8 mg dexamethasone, whereas Group B received 25 mL of 0.25% ropivacaine with 8 mg dexamethasone in Adductor Canal Block (ACB) administered in immediate postoperative period. Visual Analogue Scale (VAS) score and Functional Activity Score (FAS) was recorded for next 24 hours. Duration of postoperative analgesia was determined based on time in hours at which rescue analgesia was required. The analysis was performed using STATA (14.2). Independent sample t-test was applied to contrast the mean rescue analgesia time in hours across groups. A p-value <0.05 was considered statistically significant.

Results: Out of the 211 patients screened, 81 met the inclusion criteria. Eleven patients refused to participate, and 70 patients were finally randomised. The baseline parameters, viz., age, gender, and American Society of Anaesthesiologists (ASA) grade, was similar across groups. The mean±SD rescue analgesia time was significantly higher in Group A compared to Group B (12.91±2.13 vs 9.14±2.07, p-value<0.001). Similarly, the VAS and FAS profile was better in Group A compared to Group B. No side-effect was noted in either group.

Conclusion: Addition of Buprenorphine as a perineural adjuvant significantly improved the duration of analgesia, as well as VAS and FAS profile in contrast to addition of only dexamethasone, without any notable side-effect/complication.

Keywords: Adjuvants, Analgesia, Nerve blocks

INTRODUCTION

Lower limb surgeries, like Total Knee Arthroplasty/Replacement (TKA/TKR) and arthroscopic procedures, rank among the most frequently performed knee surgeries. After such procedures, meticulous pain management becomes crucial to facilitate early postoperative mobility while prioritising patient comfort throughout the recovery process. Peripheral nerve blocks provide efficient pain relief and diminish the necessity for opioids, consequently lowering the associated complications linked with opioid use [1-3]. Additionally, they contribute to decreased utilisation of hospital resources, enhanced postoperative recovery, and heightened patient satisfaction [4]. Furthermore, effective postoperative pain management plays a crucial role in facilitating early ambulation and rehabilitation following knee surgery [5].

The latest promising method for postoperative analgesia following knee surgeries is the ACB, which selectively targets sensory blockade. By blocking the large sensory nerve fibers responsible for knee sensation through the Saphenous and Femoral nerves, ACB offers effective pain relief. Randomised controlled trials have demonstrated that block to the adductor canal maintains the power of the quadriceps muscles better than Femoral Nerve Block (FNB), thereby reducing weakness during knee extension and facilitating functional recovery within the initial 24 hours after knee surgeries [6-9]. ACB can be administered as either a single-shot injection or via continuous infusion using indwelling catheters. However, regardless of the administration method, Peripheral Nerve Block (PNB) catheters carry inherent risks of foreign body infections, increased healthcare costs compared to single-injection techniques, and necessitate specialised expertise for placement and management [10].

Recent research has focused on enhancing the duration of analgesia of single-injection PNB by incorporating multimodal perineural adjuvants into local anaesthetic solutions [11-13]. Two such medications, Dexamethasone and Buprenorphine, have garnered significant attention for their ability to prolong analgesia following PNB across various upper and lower extremity surgical procedures [14-16]. The addition of Dexamethasone and Buprenorphine to a Bupivacaine Sciatic Nerve Block in the Popliteal Fossa as part of multimodal analgesia has shown enhanced analgesia, particularly evidenced by reduced pain scores within 24 hours [15].

The question remains unanswered regarding whether a combination of multiple perineural adjuvants can sufficiently prolong the duration of analgesia from a single-injection adductor canal nerve blockade to provide comparable pain relief to continuous catheter PNB for

knee surgery patients. Additionally, it is unclear whether the use of multiple additives can improve pain severity in knee surgery patients. A double-blind randomised controlled trial was conducted to compare the duration of postoperative analgesia provided by addition of Buprenorphine and Dexamethasone v/s addition of Dexamethasone alone to Ropivacaine in ultrasound-guided block to the adductor canal in knee surgery patients. The FAS and VAS profiles, along with any adverse effects, were also contrasted across groups.

MATERIALS AND METHODS

A double-blinded randomised controlled trial was conducted in orthopaedic and replacement operation theatre of Shree Krishna Hospital, Pramukhswami Medical College, Anand, Gujarat, India, between February 2023 and March 2024 over a duration of 14 months. The study was approved by Institutional Ethics Committee-2 at Bhaikaka University, Karamsad, Anand, Gujarat-388325 (Approval number IEC/BU/141/Faculty/10/19/2023). The study was also registered with Clinical Trial Registry of India (CTRI) with registration number CTRI/2024/03/064838.

Inclusion criteria: Patients with ASA I to III physical status of either sex within age group of 18 to 75 years, undergoing knee or below-knee surgery in one or both limb under spinal anaesthesia with a defined dose of 0.5% Bupivacaine heavy (3.5 mL) without any additives were included in the study.

Exclusion criteria: Patients with a known allergy to local anaesthetic drugs, or undergoing surgery under general anaesthesia, or having any local site infection, or history of bleeding diasthesis, or in case of any intraoperative change in plan of anaesthesia from spinal to general were excluded from the study.

Sample size: In absence of any reliable regional data on duration of postoperative analgesia with adjuvants used in the study, a moderate effect size of 0.7 was considered clinically important. With this effect size, a sample of size 32 was needed to achieve 80% power, allowing for 5% type I error. The sample size was inflated to 35 to account for lost to follow-up or death.

Patients eligible to be included in the study were approached and explained about the study. After obtaining written informed consent, the eligible patients were included in the study. Study participants were randomised into group A and group B through a balanced randomisation process using web-based programme viz., WINPEPI. The randomisation treatment was kept in serially numbered opaque closed envelopes. A member of Central Research Services at Bhaikaka University, who was not involved in the study, performed the entire process. The envelopes were opened after the informed consent process, and the Adductor Canal Nerve Block with respective adjuvants was administered. Group A participants received Inj. Ropivacaine (0.25%) 25 mL + Inj. Dexamethasone (8 mg) 2 mL + Inj. Buprenorphine (150 µg) 0.5 mL, while Group B participants received Inj. Ropivacaine (0.25%) 25 mL + Inj. Dexamethasone (8 mg) 2 mL + Inj. Normal Saline (0.5 mL), totalling 27.5 mL in the ACB under real-time Ultrasound-Guided (USG) guidance [17].

Assessment: Two different types of pain scores, namely the VAS, a 10 cm scale, with a score marked after enquiring the amount of pain between 0 which indicates 'no pain' to 10 indicating 'worst possible pain' and FAS, is a qualitative score to assess basic functionality and comfort of patient postoperatively, were utilised to evaluate the patient's pain levels and qualitative functioning postsurgery. FAS was recorded on the basis of basic activities which the patient could perform, defined in the form of sitting comfortably on the bed, getting out of bed, walking inside the room, taking a stroll comfortably and climbing stairs. The score was recorded as A, B, or C, where A indicated 'no limitation in performing all the basic activities,' B indicated 'moderate limitation' in performing the basic activities, and C indicated 'significant limitation' [18].

By utilising both VAS and FAS scores, the study aimed to comprehensively assess the analgesic efficacy of the ACB technique with the addition of multiple perineural adjuvants. The combined use of these two types of scores provides a more holistic understanding of the patient's pain experience and functional outcomes following the procedure as compared to the single quantitative source.

VAS score were recorded postoperatively at 0, 2, 4, 6, 8, 10, 12, 16, 20, and 24 hours, and FAS score were recorded postoperatively at 2, 4, 6, 8, 10, 12, 16, 20, and 24 hours. The deduction of FAS assessment between 0-2 hours was done by taking into consideration that the patient would still be under the effect of spinal anaesthesia immediately postsurgery which was provided preoperatively, hence the motive of qualitative assessment of the patient on the basis of their ability to perform certain tasks would not have been able to be executed effectively . Hence the FAS score assessment was done from the 2nd hour onwards. Time for requirement of 1st rescue analgesia was noted in hours. Injection tramadol 50 mg intravenously was given as a rescue analgesic whenever the patient fulfilled the criteria for giving rescue analgesia, i.e., patient having a VAS score of ≥3 or having a FAS of C, or both. One investigator, unaware of the drugs involved, was responsible for assessment at all the time points.

Simultaneously, side-effects of addition of the opioid, i.e., buprenorphine, perineurally were inquired with each time the VAS as well as FAS scores were inquired. Common side-effects like nausea, vomiting, dizziness, or sedation, as well as any unexpected side-effects (if any) were assessed and noted.

STATISTICAL ANALYSIS

The analysis was performed using STATA (14.2). Descriptive statistics {Mean±SD, Frequency (%)} were used to portray the baseline profile of the study population and clinical outcomes. An independent sample t-test was applied to contrast the mean rescue analgesia time in hours across groups. The Chi-square test or Fisher's exact test was applied to assess the rescue analgesia requirement in terms of VAS and FAS scores. A p-value of <0.05 was considered statistically significant.

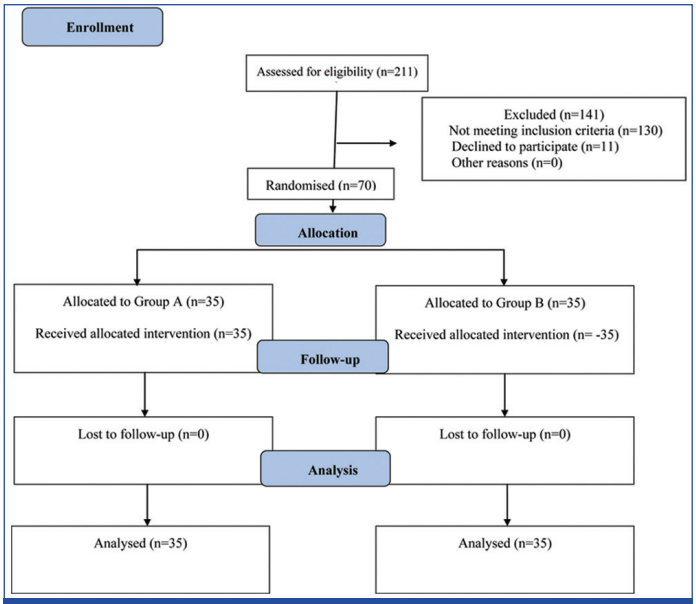
RESULTS

A total of 211 patients were screened for eligibility, and 81 were found to be eligible to participate in the study. Out of these 81 eligible patients, 11 refused to participate, resulting in a total of 70 patients being enrolled in the study. These participants were randomly assigned to either group A or B. All of these 70 participants tolerated the anaesthesia block without any adverse effect and none of them needed shifting to general anaesthesia instead of spinal anaesthesia. Furthermore, no lost to follow-up was noted, as depicted in CONSORT diagram [Table/Fig-1].

The mean±SD age of the participants was similar across groups (52.34±19.91 years vs. 50.83±18.05 years). Similarly, the gender distribution as well as ASA grades was comparable across groups [Table/Fig-2].

The mean±SD rescue analgesia time was significantly higher in group A compared to group B (12.91±2.13 vs. 9.14±2.07, $p<0.001$) [Table/Fig-3]. Known side-effects of buprenorphine, viz., nausea, vomiting, dizziness, hypotension and sedation, along with unexpected side-effects, were noted every time the VAS and FAS scores were recorded. None of the participants complained of any side-effects (known or unexpected) related to opioid included in study over the period of 24 hours after administration of the adductor canal nerve block.

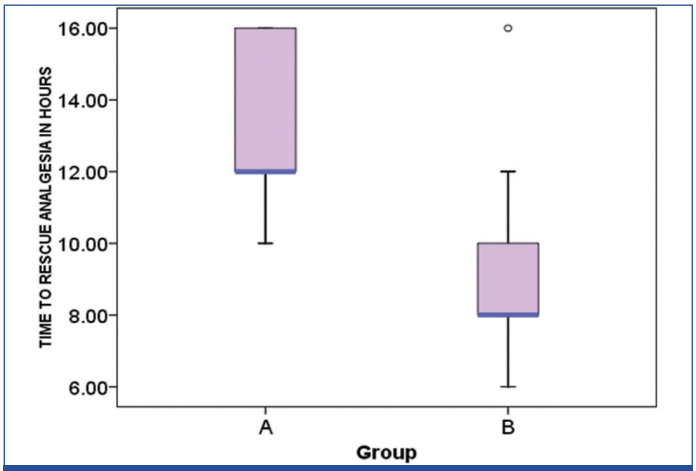
The frequency of the patients requiring the rescue analgesia on the basis of their assessment through VAS score was recorded. In Group B, six participants required Tramadol six hours postoperatively, and most needed it before 10 hours. In contrast, not a single participant



[Table/Fig-1]: CONSORT flow diagram.

Parameters	Group A (n=35)	Group B (n=35)	p-value
Age (years) (Mean±SD)	52.34±19.91	50.83±18.05	0.7406*
Gender-Male	18 (51.4%)	16 (45.7%)	0.63†
Female	17 (48.6%)	19 (54.3%)	
ASA Classification II	15 (42.9%)	16 (45.7%)	0.81†
III	20 (57.1%)	19 (54.3%)	
Rescue analgesia time in hours (Mean±SD)	12.91±2.13	9.14±2.07	<0.0001*

[Table/Fig-2]: Baseline profile and rescue analgesia of the participants.
*Independent sample t-test
†Chi-square test



[Table/Fig-3]: Box plot portraying rescue analgesia time across groups.

in Group A required tramadol till 10 hours postoperatively and most participants needed it between 12 to 16 hours [Table/Fig-4]. Similarly, the frequency of the patients requiring the rescue analgesia based on their qualitative assessment in terms of the FAS Score was noted. A similar trend was observed with most participants requiring rescue analgesia in 4-10 hours in Group B in contrast with most requiring it in 10-20 hours in Group A [Table/Fig-5]. This corroborates with the mean±SD rescue analgesia time.

With the help of assessment of both VAS and FAS scores, it was observed that though the VAS score numerically reached a value of 3 in few patients at a particular time, if the FAS score at the same hour is A or B, the participants was still comfortable, and rescue analgesia requirement was delayed which could have been given earlier if only one scale had been taken into consideration. In those patients, rescue analgesia was needed when FAS score reached C along with a VAS of ≥3.

Hours	Group A (n=35)	Group B (n=35)	p-value*
0	0	0	NA†
2	0	0	NA
4	0	0	NA
6	0	6	0.025‡
8	0	16	<0.001
10	6	17	0.005
12	25	10	<0.001
16	19	6	0.001
20	1	0	>0.99‡
24	0	0	NA

[Table/Fig-4]: Frequency of patients requiring rescue analgesic as per the VAS Score (≥3).
*Chi-square test; †NA: Not applicable; ‡Fisher's-exact test

Hours	Group A (n=35)			Group B (n=35)			p-value†
	A	B*	C*	A	B*	C*	
0	35	0	0	35	0	0	NA‡
2	34	1	0	35	0	0	>0.99
4	34	1	0	17	18	0	<0.001§
6	10	25	0	0	31	4	0.001§
8	0	35	0	0	18	17	NA
10	1	27	7	0	19	16	>0.99
12	0	7	28	0	28	7	NA
16	0	22	13	3	31	1	0.24
20	15	20	0	17	17	1	0.024§
24	31	4	0	33	2	0	0.67

[Table/Fig-5]: Frequency of patients requiring rescue analgesic as per the FAS Score.
*The values of FAS 'B' and 'C' were clubbed to calculate the p-value.
†Fisher's-exact test; ‡NA: Not applicable; §Chi-square test

DISCUSSION

Knee surgeries, including TKA and Arthroscopy procedures, tension band wiring etc., are commonly performed lower limb surgeries. Effective pain management is crucial in the postoperative period to facilitate early mobilisation and ensure patient comfort. Unfortunately, reliance on opioids for pain management can lead to various complications, including sedation, respiratory depression, nausea, vomiting and constipation. These opioid-related adverse effects can significantly impact patient recovery and overall wellbeing. Continuous epidural anaesthesia or FNB can provide effective pain relief after knee surgeries, but they are associated with adverse effects such as haemodynamic instability and muscle weakness, respectively. This weakness can impede postoperative mobilisation, delaying recovery [6,7].

Implementing regional anaesthesia techniques, such as ACB, has emerged as a promising approach for postoperative pain control following knee surgeries. ACB targets specific nerves in the adductor canal, providing effective analgesia while minimising systemic opioid exposure. By reducing opioid requirements, ACB can help mitigate opioid-related adverse effects and enhance patient recovery [1-3].

The ACB has emerged as a promising alternative for postoperative analgesia following knee surgeries. Unlike epidural anaesthesia or FNB, ACB primarily targets sensory nerve fibers, preserving motor function and minimising muscle weakness and avoiding any haemodynamic complications. By selectively blocking sensory innervation via the saphenous nerve, ACB effectively alleviates pain without compromising muscle strength [6-9]. Research indicates that the inclusion of dexamethasone and buprenorphine in local anaesthetic solutions can enhance the duration and effectiveness of single-injection ACB. Dexamethasone, recognised for its potent anti-inflammatory properties, has been observed to prolong nerve block duration by mitigating inflammation and impeding pain signalling pathways [15].

This is the first study to point out the benefits of using multiple perineural analgesics as compared to a single agent in ACB. This study was conducted with the purpose of finding whether there is any added benefit of using multiple adjuvants for perineural analgesia in ACB and whether extended and efficient postoperative analgesia can be provided or not with or without side-effects, consequently enhancing patient outcomes, satisfaction, and reducing morbidity. The study found out that by utilising multiple adjuvants for the application of ACB, improved pain scores can be achieved among patients postoperatively.

YaDeau JT et al., did a randomised controlled trial to identify the effectiveness of addition of both dexamethasone and buprenorphine perineurally to bupivacaine in sciatic nerve block vs intravenously [15]. They compared three groups: one control group with addition of single adjuvant, dexamethasone, given intravenously; another study group with both buprenorphine and dexamethasone intravenously; and third study group with buprenorphine and dexamethasone given perineurally and found that the duration of analgesia was significantly higher in both study groups. Similarly, this study compared the perineural addition of multiple drugs in adductor canal nerve block.

The basis of this study was also to find out the effectiveness of using the ACB for adequate analgesia along with motor functioning with retainment of quadriceps strength, post-block performance, in contrast to the commonly used FNB, which is often associated with quadriceps weakness [6,7]. Kejriwal R et al., conducted a study to find the effectiveness of the ACB as compared to FNB for Anterior Cruciate Ligament (ACL) reconstruction with hamstring autograft [19]. The study concluded that an FNB has minimal analgesic effect on the postsurgical care of patients undergoing ACL reconstruction with hamstring autograft, while ACB significantly causes improved qualitative motor function as well as reduction in pain scores among patients. Similarly, in this study it was found that along with better pain relief post knee surgeries, patients had better qualitative motor functioning that was assessed with the FAS score effectively.

In this randomised controlled trial, the ACB was performed in midsection of the adductor canal, which further resulted in a 100% success rate, with an averagely 9-11 hours of postoperative analgesia and along with retained motor functioning post-diminution of neuraxial block. This was accompanied by improved VAS and FAS scores. The combination of drugs was instilled in the mid-portion of the adductor canal, which not only gave a clear visualisation of the neurovascular contents of the canal but also resulted in almost 100% success of the block in providing analgesia postoperatively, along with improvement in both the pain assessment and the functional activity scores, i.e., the VAS and the FAS scores, respectively.

Tamam A et al., compared the effectiveness of USG ACB when it was given in the proximal, mid, or distal part of the adductor canal after knee arthroscopy [20]. The study concluded that the mid-ACB approach offered significantly lower tramadol consumption and postoperative VAS values compared to the distal ACB groups. Fan Chiang YH et al., examined the true impact of ACB in the mid-portion of the adductor canal on its analgesic effect and motor function following knee surgery [21]. After demonstrating the motor-sparing effect of adductor canal compared to femoral nerve using a corrected classification system, the authors found that the mid-portion of adductor canal is the preferred analgesic technique for knee surgery.

This study had two groups which received single and two adjuvants along with the local anaesthetic, respectively and it was found that utilising multiple adjuvants indeed increased the amount of analgesia provided in view of duration, VAS and FAS scores as compared to a single adjuvant along with a local anaesthetic agent. Turner JD et al., investigated the efficacy of Single-Injection Adductor Canal Block (SACB) with multiple adjuvants compared to Continuous Adductor Canal Blockade (CACB) for primary TKA in which they found out that the single injection ACB with bupivacaine and multiple adjuvants offered more pain relief as compared to the continuous block of the saphenous nerve for perioperative pain management in TKA patients, with the effect potentially extending beyond 30 hours [10].

This study primarily focused on addition of buprenorphine in a dose of 150 µg to the combination of drugs and observed that there was an increase in the duration of analgesia obtained (12.91 hours in group A vs. 9.14 hours in group B) when buprenorphine was added to ropivacaine and dexamethasone in giving adductor canal block, compared to addition of dexamethasone alone. Kosel J et al., investigated the impact of adding the long-acting opioid buprenorphine as an adjuvant to the local anaesthetic agent in femoral nerve blockade for postoperative pain relief following knee replacement [22]. Their study concluded that the involvement of buprenorphine at a dose of 0.3 mg to the local anaesthetic agent increases the effectiveness of pain relief provided by the PNB and prolongs its duration.

From the detailing described in the results section, it was observed that group A has a better analgesic profile which is reflected from their delayed functional derangement as well as their delayed requirement of rescue analgesic as compared to the group B. Thus, it can be inferred that addition of both buprenorphine and dexamethasone to ropivacaine improves both the analgesic profile and the qualitative functioning capacity of the patient compared to addition of a single agent, dexamethasone, to ropivacaine.

Limitation(s)

This study is a single-centre study, and the study population might not be a representative of a larger population. A multicentric trial or single-centre trials conducted across different regions will help strengthen the evidence base.

CONCLUSION(S)

Addition of multiple adjuvants perineurally to a local anaesthetic agent in adductor canal block provides better and prolonged analgesic effect as compared to addition of a single adjuvant. Furthermore, neither anticipated nor unanticipated side-effects or complications were observed with addition of single or multiple adjuvants. This method may be preferred over other methods like epidural anaesthesia or continuous peripheral nerve catheters, which are prone to side-effects like haemodynamic instability, infection and higher cost. Combining evaluation with VAS and FAS together provides a better pain assessment and management as compared to a single scale.

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