Section: Anaesthesia

Original Research Article

A COMPARATIVE STUDY OF MgSO4 AND DEXMEDETOMIDINE AS ADJUVANTS IN COMBINED ACB (ADDUCTOR CANAL BLOCK) AND IPACK (INTERSPACE BETWEEN POPLITEAL ARTERY AND POSTERIOR CAPSULE OF KNEE BLOCK) FOR POSTOPERATIVE ANALGESIA AFTER UNILATERAL TOTAL KNEE ARTHROPLASTY: A RANDOMISED CONTROL STUDY

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ABSTRACT

Background: Total Knee Arthroplasty (TKA) is associated with significant postoperative pain, which can hinder early ambulation and rehabilitation. The Adductor Canal Block (ACB) combined with the Interspace between the Popliteal Artery and Capsule of the Knee (IPACK) block is commonly employed for pain management. The use of adjuvants such as Dexmedetomidine and Magnesium Sulphate in these blocks may further enhance analgesic efficacy. This study aims to compare the effectiveness of Dexmedetomidine versus Magnesium Sulphate in prolonging postoperative analgesia and facilitating early ambulation in TKA patients.

Materials and Methods: A randomized, prospective, comparative study (CTRI/2025/03/083361) was conducted at Dr. Moopen's Medical College (DMMC), Wayanad. A total of 98 patients aged 40- 75 years, belonging to ASA Class I-II, undergoing unilateral TKA under subarachnoid block (SAB), were recruited. Patients were randomly assigned into two groups. Group M (n=49): Received ACB + IPACK block with Magnesium Sulphate (MgSO4) as an adjuvant. Group D (n=49): Received ACB + IPACK block with Dexmedetomidine as an adjuvant. Pain scores using the Numerical Rating Scale (NRS) at 4, 8, 12, and 24 hours, both at rest and during ambulation, were assessed. Additional parameters included the time to first analgesic request, total analgesic requirement (tramadol consumption in 24 hours), and patient satisfaction. Statistical analysis was performed using the Mann-Whitney U test due to non-normal distribution of data.

Results: The mean age of participants was 62.74 ± 6.77 years, with a majority being female (82 females, 16 males). The mean weight was 63.64 ± 6.28 kg, and the mean BMI was 25.51 ± 2.90 kg/m². The distribution of ASA status was 45 patients in ASA I and 53 in ASA II. The mean duration of analgesia was significantly longer in Group D (Dexmedetomidine) (24.08 ± 7.315 hours) compared to Group M (Magnesium Sulphate) (17.92 ± 7.315 hours) (p <

0.001). The total tramadol requirement in the first 24 hours was slightly lower in Group D (63.04 mg/kg) compared to Group M (64.24 mg/kg). Pain scores, measured using the Numerical Rating Scale (NRS), were lower in Group D at all time points. The statistical analysis using the Mann-Whitney U test confirmed that Dexmedetomidine provided significantly longer analgesia than Magnesium Sulphate ($p< 0.001$).

Conclusion: Dexmedetomidine significantly prolonged postoperative analgesia duration compared to Magnesium Sulphate. It also resulted in lower pain scores and reduced tramadol consumption in the first 24 hours. While both adjuvants provided effective analgesia, Dexmedetomidine demonstrated superior efficacy in prolonging pain relief and reducing opioid consumption, making it the preferred choice for postoperative pain management in TKA patients.

Keywords: Total Knee Arthroplasty, Dexmedetomidine, Magnesium Sulphate, Adductor Canal Block, IPACK Block, Postoperative Analgesia.

INTRODUCTION

It is common for patients undergoing Total Knee Arthroplasty (TKA) surgeries to experience moderate to severe pain in the post-operative period (first 24-48 hours) resulting in to delayed mobilization and hence delayed recovery from surgery.[1] It leads to ineffective post operative physiotherapy, reduced patient satisfaction, increased hospital stays, increased post-operative analgesic requirement and increased overall cost of treatment.

In recent years, effective postoperative analgesia has become a pivotal focus in enhancing recovery outcomes for individuals undergoing total knee arthroplasty. With the increasing prevalence of such surgical procedures, optimizing pain management strategies has taken centre stage in clinical practice. Epidural analgesia, adductor canal block, continuous femoral or adductor canal block or even intra articular injection of local anesthetics were proven to be effective in controlling knee pain after TKA surgeries.[2-4] Prolongation of subarachnoid block using various adjuvants is also a known method of post-operative analgesia.[5] The Adductor Canal Block (ACB) has been commonly utilized to enhance pain relief following TKA.[6] The primary limitation of this block is that it does not encompass the posterior knee area, potentially resulting in moderate to severe pain and delay in the patient's ability to ambulate. To address this issue, the IPACK (interspace between the popliteal artery and the Capsule of the Posterior Knee) block can be administered alongside the ACB.1 So both these blocks can be combined for effective control of post-operative pain and helps in early ambulation. In order to further prolong the analgesia adjuncts like Dexmedetomidine and Magnesium Sulphate can be utilized as they have previously been utilized in various other block for the similar purpose.[7-9]

Among these, regional anesthesia techniques, including the ACB integrated with local anesthetic infiltration through the IPACK, have become increasingly popular. These techniques have been demonstrated to preserve motor function while effectively controlling pain, ultimately facilitating earlier ambulation and reducing hospital stays.[10] Moreover, the incorporation of adjuvants like magnesium sulphate (MgSO4) and dexmedetomidine into these blocks may further enhance analgesia, potentially lowering opioid requirements postoperatively and also improving the quality of analgesia in the postoperative period. By optimizing these techniques, healthcare providers strive to improve patient satisfaction and outcomes in the often challenging postoperative phase of TKA.[11]

This study aims to explore the comparative effects of, magnesium sulphate (MgSO4) and dexmedetomidine, when used as adjuvants in these blocks. By evaluating their efficacy in providing analgesia, we strive to identify the most advantageous adjuvant, thereby improving patient comfort and satisfaction post-surgery. Understanding the different pharmacological profiles of MgSO4 and dexmedetomidine is crucial to developing tailored pain management protocols for this population.

MATERIALS AND METHODS

This randomized prospective comparative study was done to evaluate the effectiveness of Dexmedetomidine versus Magnesium Sulphate in postoperative pain management and early ambulation when combined with IPACK+ACB block in patients undergoing TKA under subarachnoid block (SAB). We also assessed the time to 1st request of analgesic (Duration of analgesia), NRS (Numerical Scale Rating) pain score at 4,8,12 and 24 hours both at rest and during ambulation, total analgesic requirement in the post-operative period for 24 hours and patient satisfaction. Patients receiving unilateral total knee arthroplasty (TKA) in the DMMC's orthopedic department over a period of 1.5 years starting in July 2023 are the subjects of this randomized controlled study (CTRI/2025/03/083361). Duration of

analgesia (4.05 +/- 0.29, 3.51 +/- 0.82) seen in an earlier publication, Del Toro-Pagán NM, Dai F, Banack T, Berlin J, Makadia SA, Rubin LE, et al. Perineural Methylprednisolone Depot Formulation Decreases Opioid Consumption After Total Knee Arthroplasty. J Pain Res. 2022; 15:2537–46.[11] and with 95% confidence interval and 70 power; for each group, a minimum sample size of 49 is needed. For the investigation, a minimum sample size of 98 is needed.

We included Patients undergoing elective unilateral TKA, Age between 40-75 years, Belonging to ASA (American Society of Anesthesiologists) class 1 & 2, BMI (Body Mass Index) < 40, Patients with one or two comorbid conditions not interfering in their day-to-day life under control.

We excluded patients with Patients who are contraindicated to regional anesthesia, Patients with any coagulopathies and bleeding disorder, Infection at the site of block, Hepatic or renal insufficiencies, Patients who are allergic to the drugs given in the study, Regional anesthesia converted to general anesthesia.

Following institutional ethics committee approval, 98 patients undergoing elective unilateral TKA were randomly assigned to either 49 Dexmedetomidine (Group D) or Magnesium Sulphate (Group M) as an adjunct in ACB+IPACK following spinal anaesthesia. This was done using Microsoft Excel 2007 and block randomization (block size of 4). They underwent baseline tests, such as a chest X-ray, ECG, and coagulation profile, and were assessed for any comorbid conditions.

The opaque sealed envelope method with serial numbers was used for allocation concealment. An someone who was not affiliated with the researchers, the surgeon, or the anaesthetist who provided patient care prepared the sealed envelopes and randomization. Envelopes were opened on the day of surgery in the OR and then the patient was allotted as per the envelope.

The patient who undergoes the procedure was blinded. Hence, the study conducted is single blind. Patients were taught how to read the numerical rating scale (NRS) of pain during the preoperative session after their informed written agreement was obtained. They were premedicated with Tab. Pantoprazole 40mg, night before surgery and Tab. Metoclopramide 10mg orally on morning of surgery as aspiration prophylaxis and were asked a fasting period of at least 8 hours of solids and 2 hours of clear liquid.

On the day of surgery, 18 G cannula was secured in upper limb in the pre-operative area. Patient was shifted to the operation theatre and SLR (straight leg raising) test was done. All the base line monitor like ECG, BP, pulse oximetry, heart rate, was monitored. Based on the anxiety level of each patient 0.5-1 mg Inj. Midazolam was given IV prior to administering SAB (Subarachnoid Block).

All patients positioned for SAB in left or right lateral position. SAB with 2.8 ml of 0.5% Heavy bupivacaine with 60 micrograms of buprenorphine as adjuvant added given using 25G Quincke spinal needle, at the L3-L4 interspaces (or, alternately, the L2-L3 or L4-L5 interspaces) under stringent aseptic conditions. Patients were made supine after 5 minutes of performing SAB.

During the immediate preoperative phase, all patients received ACB under high- frequency ultrasound guidance, which allowed for the identification of the adductor canal beneath the Sartorius muscle. A 23-gauge Quincke needle was used to inject 7.5 ml of 0.25% Bupivacaine, 7.5 ml of 2% Lignocaine with Adrenaline, and 4 mg Dexamethasone into the AC. (Total volume = 15 ml + 2 ml).

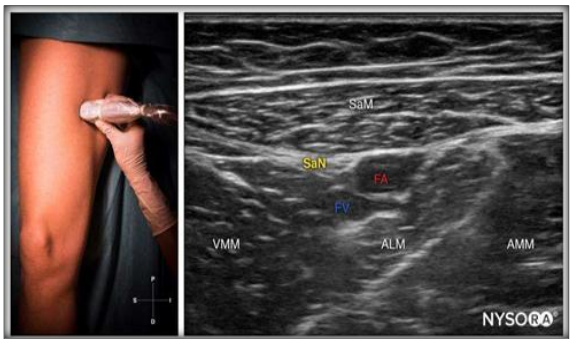

Figure 1: Probe and Needle Position for Adductor Canal Block (27)

IPACK, in which the patient was positioned supine with their knee in a 90° flexion posture. A 23 G Quincke needle is inserted from the medial aspect of the knee from an anteromedial to posterolateral orientation in a plane between the popliteal artery and the femur, and a high-frequency ultrasound probe is placed in the popliteal crease. After positioning the tip of the 23 G Quincke needle 1-2 cm past the artery's lateral border,

7.5 ml of 0.25% Bupivacaine, 7.5 ml of 2% Lignocaine, Adrenaline, and 4 mg Dexamethasone were administered. (Total volume = 15 ml + 2 ml).

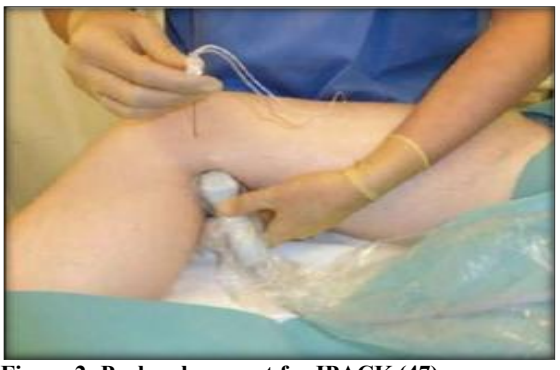

Figure 2: Probe placement for IPACK (47)

Group D received the blocks with an adjuvant of 1 mcg/kg of Dexmedetomidine.

Group M received the blocks with an adjuvant of 15 mg/kg Magnesium Sulphate.

Following surgery, all patients received an intravenous injection of paracetamol (15 mg/kg) every eight hours as a baseline analgesic, beginning six hours after the block was performed. Patients were given rescues analgesic when the NRS (Numerical rating Scale) >4. The 1st line rescue analgesia was Inj. Tramadol 1mg /kg intravenously, 2nd line Inj. Diclofenac 1mg/kg aqueous solution as intravenous infusion and 3rd line as post-operative epidural anaesthesia SOS. Patients' satisfaction assessed.

Data collected was analyzed in SPSS software. Continuous variables were expressed in mean ± SD, and Categorical variables were expressed in frequency and percentage. Depending on whether the data is normal, either the Mann-Whiteny U test or the independent student t-test will be employed to compare the data between the two groups in continuous variables. Normality was checked using Kolmogorov Smirnov test. To identify the association between categorical variables, Chi square test was utilized. p-value <0.05 was deemed as statistically significant.

RESULTS

Group M consisted of 49 patients who received magnesium sulphate, while Group D consisted of 49 patients who received dexmedetomidine. There were 98 participants in all. The demographic details of patients in both the groups were comparable.

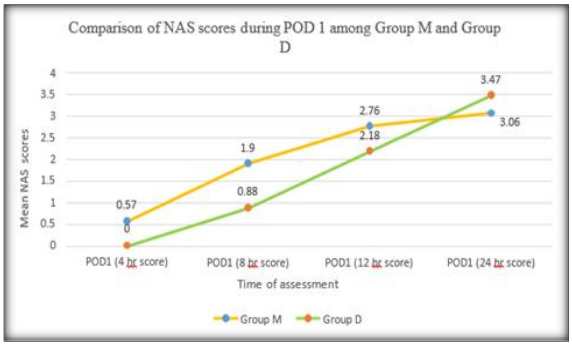

Figure 3: Comparison of efficacy of analgesia during rest period

Group D had lower NAS scores for the first 12 hours of the ambulatory period than Group D, although this difference was determined to be statistically only important during the third observational quarter. [Table 2]

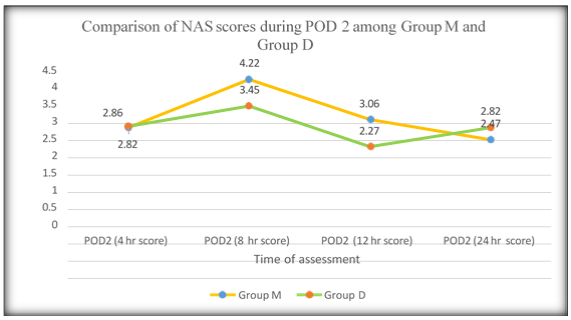

Figure 4: Comparison of NAS scores during POD 2 among Group M and Group D

Rescue analgesic requirement in the post-operative period

Group M required a higher dosage than Group D. The Mann Whitney U test was used to evaluate Group M and Group D's need for rescue analgesics using diclofenac (second time). Group M had a greater dosage required than Group D. However, as table 25 shows, this difference was determined to be statistically significant p<0.001). [Table 3]

Table 1: Descriptive statistical parameters of Group M and Group D

Parameters	Group M Mean (Standard deviation)	Group D Mean (Standard deviation)
Age	61.88 (7.008)	63.61 (6.483)
Weight	64.24 (6.833)	63.04 (5.686)
Height	158.76 (7.064)	157.65 (6.996)
BMI	25.545 (2.848)	25.484 (3.000)
POD1 (4hr score)	0.57 (0.736)	0.00 (0.000)
POD1 (8hr score)	1.90 (1.195)	0.88 (0.696)
POD1 (12hr score)	2.76 (1.031)	2.18 (0.834)
POD1 (24hr score)	3.06 (1.232)	3.47 (1.293)
POD2 (48hr score)	2.82 (1.302)	2.86 (0.866)
POD2 (8hr score)	4.22 (1.327)	3.45 (1.276)
POD2 (12hr score)	3.06 (1.663)	2.27 (1.617)
POD2 (24hr score)	2.47 (1.002)	2.82 (1.202)
1st analgesic(hrs)	17.92 (7.237)	24.08 (6.031)
NRS	4.61 (0.702)	4.63 (0.727)
Tramadol dose	64.24 (6.833)	63.04 (5.686)
Diclofenac Dose	35.69 (32.921)	11.22 (23.967)

Table 2: Comparison of NAS scores during POD 1 for Group M and Group D using Mann- Whitney U test at the end of 4 hours, 8 hours, 12 hours and 24 hours

Parameters	Group	N	Mean Rank	Sum of Ranks	Mann Whitney U	Asymp. Sig.(2-tailed)
POD1 (4hr score)	Group M	49	60.50	2964.50	661.5	0.000
	Group D	49	38.50	1886.50		
POD1 (8hr score)	Group M	49	61.84	3030.00	596.0	0.000
	Group D	49	37.16	1821.00		
POD1 (12hr score)	Group M	49	55.51	2720.00	906	0.025
	Group D	49	43.49	2131.00		
POD1 (24hr score)	Group M	49	45.83	2245.50	1020.5	0.189
	Group D	49	53.17	2605.50		

Table 3: Comparison of Rescue analgesic requirement in the post-operative period

Analgesic (dose)	Group	N	Mean Rank	Sum of Ranks	Mann Whitney U	Asymp. Sig.(2-tailed)
Tramadol	Group M	49	53.53	2623.00	1003	0.159
	Group D	49	45.47	2228.00		
Diclofenac	Group M	49	59.68	2924.5	701.5	0.001
	Group D	49	39.32	1926.50		

DISCUSSION

The study included 98 participants aged 45 to 75 years (mean age: 62.74 ± 6.77 years). Compared to previous studies, the participants in this study were generally younger, though the age distribution remained similar. The gender distribution showed a higher proportion of females (83.7%) compared to other studies, which may influence pain perception and analgesic requirements.

Anthropometric data such as weight, height, and BMI were comparable to previous studies, indicating a similar patient demographic for total knee arthroplasty (TKA). The mean weight was 63.64 kg (SD = 6.28 kg), the mean height was 158.2 cm (SD = 7.02 cm), and the mean BMI was 25.51 kg/m² (SD = 2.90 kg/m²). These similarities suggest that the findings are generalizable to similar patient populations.

POD 1 (at rest): NAS score after 4, 8, 12, 24 hours

In contrast to magnesium sulphate, dexmedetomidine produced better early postoperative analgesia, as indicated by reduced NAS scores at 4 and 8 hours (0.00 vs. 0.57, $p < 0.05$) and 0.88 vs. 1.90, $p < 0.05$). However, at 12 hours (2.18 vs. 2.76, p =

0.08) and 24 hours (3.47 vs. 3.06, p = 0.12), magnesium sulphate showed comparable or slightly better pain relief. These results are in line with another study that compared dexmedetomidine and magnesium sulphate as adjuvants to bupivacaine in spinal anesthesia for infraumbilical surgeries. That study found that the dexmedetomidine group had significantly lower VAS scores at 4 and 8 hours (0.5 ± 0.3 vs. 1.2 ± 0.4, $p < 0.05$) compared to 1.8 ± 0.6, $p < 0.05$). However, there was no significant difference in the scores at 12 and 24 hours (2.3 ± 0.7 vs. 2.6 ± 0.8, p = 0.08) and 3.4 ± 0.9 vs. 3.1 ± 1.0, p = 0.12). (123) This result suggests that dexmedetomidine provides more effective pain relief in the early postoperative period, whereas magnesium sulphate may sustain analgesia better at later time points. Both agents, however, significantly reduce postoperative pain and can be selected based on the required duration of analgesia.

Duration after which 1st post-operative analgesia was sought

The current study reports a mean time to first post-operative analgesia of 21 hours with a standard deviation of 7.315 hours, indicating a consistent pattern in the prolonged analgesic effects of dexmedetomidine. However, when analyzing the two subgroups within this dataset, Group D (which received dexmedetomidine) required analgesia significantly later, at an average of 24.08 hours, while Group M required analgesia sooner, at 17.92 hours. This suggests that dexmedetomidine plays a role in extending the pain-free period postoperatively.

Similarly, Ibrahim et al.'s study shows statistically significant results ($P < 0.001$) showing that Group D had analgesia for a longer period of time than Group MS. In particular, the analgesic duration in Group D was 664.33 ± 30.02 minutes (~11.07 hours), but it was much less in Group MS at 386 ± 30.69 minutes (~6.43 hours).[12] The results of Ibrahim et al.'s study also show that Group D's sensory and motor block durations were longer than Group MS's (349 ± 25.91 minutes for sensory block and 288

± 26.35 minutes for motor block) (590.33 ± 27.97 minutes for sensory block and 398.66

± 26.48 minutes for motor block).[12] All of these variations were statistically significant ($P < 0.001$), supporting the idea that dexmedetomidine extends the duration of the discomfort.

While the absolute durations differ between the two studies, the underlying trend remains the same: dexmedetomidine significantly prolongs the duration of analgesia, leading to a delayed requirement for post-operative analgesia. In showing that patients receiving dexmedetomidine

had a longer duration of pain relief than those in the other groups, the current study's findings are consistent with Ibrahim et al.'s investigation.[12] This reinforces the potential of dexmedetomidine as an effective adjuvant in regional anesthesia techniques for post-operative pain management, reducing the immediate need for additional analgesics and potentially improving patient comfort and recovery outcomes.

The statistical analysis shows that the two studies differed significantly in the amount of time after surgery that postoperative analgesia was requested. When the DX group (present study) and Group D (Ibrahim et al.12 research) were compared, there was a moderate effect size (Cohen's d = -0.43) and a statistically significant difference ($p = 0.038$), suggesting that patients in Group D waited longer before needing analgesia. Similarly, the DM group (current study) and Group D (Ibrahim et al12 study) comparison approached significance ($p = 0.059$), with a moderate effect size (Cohen's d = -0.39), suggesting a potential but less conclusive difference. However, the most striking finding was the significant difference between the M group (current study) and M group (Ibrahim et al's study) ($p < 0.001$, Cohen's d = -1.18), indicating a large effect size. This suggests that the two M groups were likely subject to different study conditions, patient responses, or intervention protocols, resulting in markedly different analgesia requirements.[12] Overall, the M groups from the two datasets differed considerably from the DX and DM groups in terms of analgesic duration, indicating that study design modifications, analgesic methods, or patient characteristics need more research.

According to the study's findings, it took an average of 21 hours with a standard deviation of 7.315 hours to request an analgesic for the first time after surgery. Specifically, patients in Group M requested analgesia after an average of 17.92 hours, whereas Group D patients required analgesia after 24.08 hours, suggesting that dexmedetomidine has a prolonged analgesic effect. This observation is supported by multiple studies in the existing literature.[12]

Rescue analgesic requirement in the post-operative period

Group M in the current study required more tramadol for their initial rescue analgesic than Group D, although the difference was not statistically significant ($U = 1003$, $p = 0.159$). In contrast, the second rescue analgesic requirement using diclofenac was significantly higher in Group M than in Group D ($U = 701.5$, $p < 0.001$), indicating a greater need for additional pain relief in Group M.

In contrast to prior research, Mou et al. (2022) found that the dexmedetomidine group required considerably less rescue analgesic than the magnesium sulfate group ($p = 0.042$), indicating that dexmedetomidine is a more effective analgesic.7 Similarly, Tang et al. (2022) observed that the iPACK + SACB group had a considerably lower postoperative analgesic demand than the SACB-only group ($p < 0.01$), demonstrating better pain control with the combined block.1These findings align with the present study, where dexmedetomidine reduced analgesic requirements, particularly in later postoperative periods, as reflected in the significantly lower need for diclofenac ($p < 0.001$).1 However, the lack of statistical significance in tramadol use ($p = 0.159$) suggests that the early postoperative analgesic effect may not differ substantially between the two groups.

CONCLUSION

Dexmedetomidine demonstrated superior and prolonged analgesic effects compared to $MgSO_4$, making it a more effective choice for postoperative pain management in TKA patients.

Limitations: The study was conducted on a small sample size. Larger studies are needed to confirm these results. This research was conducted in single medical centre, which may not represent the practices and patient populations of other institutions, potentially limiting the external validity of the findings.

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Conflict of interest: Nil

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