ISSN: 2581 – 3633
PubMed - National Library of Medicine - ID: 101745081

International Journal of Medical Science and Advanced Clinical Research (IJMACR)

Available Online at:www.ijmacr.com

Volume – 7, Issue – 6, December - 2024, Page No. : 130 – 140

Ultrasound Guided Adductor Canal Block for Postoperative Pain Relief after Total Knee Arthroplasty with Levobupivacaine versus Levobupivacaine With Dexmeditomedine- A Randomized Clinical Study

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How to citation this article: Dr. Kishore Keerthy N, Dr. Vinod C.N, Dr. Sarala H.S, Dr. Noel Jojy, "Ultrasound Guided Adductor Canal Block for Postoperative Pain Relief after Total Knee Arthroplasty with Levobupivacaine versus Levobupivacaine With Dexmeditomedine- A Randomized Clinical Study", IJMACR- December - 2024, Volume – 7, Issue - 6, P. No. 130 – 140.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Effective post-operative analgesia is crucial for enhancing recovery and reducing opioid requirements in patients undergoing total knee arthroplasty (TKR). Levobupivacaine is a commonly used local anaesthetic in adductor canal blocks (ACB) for TKR; however, its duration of analgesia can be limited. Dexmedetomidine, an alpha-2 adrenergic agonist, is recognized for its analgesic properties and potential to extend the effects of local anaesthetics. This study evaluates the effectiveness of Levobupivacaine versus Levobupivacaine combined with Dexmedetomidine in enhancing analgesic duration and quality in patients undergoing total knee arthroplasty.

Objectives: This study aimed to assess the duration of analgesia, 24-hour opioid consumption, success of early ambulation, patient satisfaction, and to look for any adverse effects or complications in patients receiving Levobupivacaine versus Levobupivacaine with Dexmedetomidine in ACB after total knee arthroplasty.

Methods: A prospective, randomized clinical trial was conducted among a total of 100 patients with two patient groups undergoing TKA. Patients undergoing elective TKR surgeries, aged between 18 and 70 years of age and categorized under American Society of Anesthesiologists (ASA) class 1 to 3 were included in this study. Group A (50 patients) received Levobupivacaine alone in ACB, while Group B (50 patients) received a combination of Levobupivacaine with Dexmedetomidine. Heart rate and blood pressure were monitored at baseline, every 15 minutes for the first hour, then at 2, 5, 12, and 24 hours post-operatively.

Quadriceps power was recorded preoperatively and at 6, 12, and 24 hours after the block. Patient satisfaction and any adverse events were noted at 24 hours. Rescue analgesia was provided with 75 mg diclofenac or 100 mg tramadol with 4 mg ondansetron intravenously, and total 24-hour requirements for tramadol and diclofenac were documented. The data was collected were tabulated using Microsoft excel sheet and was analyzed in SPSS trial version 23.0 using chi-square test or Fishers exact test. $p<0.05$ was considered to be statistically significant.

Results: Group B showed a significantly delayed need of rescue analgesia of around 6 hours compared to Group A of around 3 hours. VAS pain scores were generally lower in Group B from 2 to 12 hours post-operatively, although a slight increase was noted at 24 hours, indicating extended pain relief. The mean total dose of rescue analgesia in Group A was significantly higher (301.5 mg) of tramadol compared to Group B (139.5 mg) of tramadol, indicating that the total dose of rescue analgesia requested is significantly higher in Group A than in Group B.

Both groups demonstrated comparable physiological stability, with no significant differences in heart rate, blood pressure, or oxygen saturation. Differences in ASA grade and BMI were noted between the groups but did not significantly affect primary or secondary outcomes.

Conclusion: Adding Dexmedetomidine to Levobupivacaine in ACB for TKR significantly enhanced the duration and quality of post-operative analgesia without compromising physiological stability. This combination reduced immediate opioid requirements and improve patient comfort, supporting its broader application in clinical settings for post-operative pain management.

Keywords: Levobupivacaine; Dexmedetomidine; adductor canal block; total knee replacement; post-operative analgesia; opioid consumption; Visual Analog Scale.

Introduction

Total knee arthroplasty (TKA) is a commonly performed surgical intervention for patients with end-stage knee arthritis or other debilitating knee conditions that severely limit mobility and reduce quality of life. This procedure has been shown to significantly alleviate pain, restore joint function, and improve overall patient outcomes. However, TKA is associated with considerable postoperative pain, which can pose a significant challenge to both patients and healthcare providers. Inadequate pain control can lead to delayed rehabilitation, prolonged hospital stays, increased opioid consumption, and potentially poorer long-term functional outcomes. Thus, effective and sustained postoperative pain management is crucial to enable early mobilization, reduce complications, and enhance recovery [1-3].

An ultrasound technique, the adductor canal block (ACB), has been developed as an alternative to femoral nerve block (FNB). Many studies report that the analgesic effect of ACB is similar to that of FNB, but with a relative sparing of quadricep strength [4] and an increase in ambulatory ability (the Time-Up-and-Go test, 10 m walk, or 30-second Chair test) [5]. Moreover, the continuous ACB, compared with the continuous FNB, is associated with a seven-fold increase in early ambulation [6]. TKA alone reduces quadriceps muscle strength [7], and many patients undergoing TKA are female or over 65 years of age. Thus, TKA patients are already at a greater risk of falls [8], underscoring the clinical

importance of preserving muscle strength, using methods such as the ACB.

Levobupivacaine, a long-acting local anesthetic, is frequently utilized in ACB to manage postoperative pain in TKA. However, despite its efficacy, the duration of analgesia with Levobupivacaine alone may be limited, leading to a need for adjunctive analgesics or increased opioid consumption as the effect diminishes [9, 10]. Recently, Dexmedetomidine, an alpha-2 adrenergic agonist known for its analgesic and sedative properties, has emerged as a potential additive to local anesthetics. When combined with Levobupivacaine, Dexmedetomidine may extend the duration of analgesia and enhance the quality of pain control by synergistically acting on peripheral and central pain pathways [11-13].

Adductor canal block (ACB) has emerged as an effective method to manage postoperative pain after Total knee arthroplasty (TKR). Previous studies have concentrated on Ropivacaine and Bupivacaine with or without Dexmeditomedine. We intend to study the post operative pain relief provided by Levobupivacaine plain versus Levobupivacaine with Dexmeditomedine as Levobupivacaine has lesser side effects than with Bupivacaine and Ropivacaine.

Objective of the Study

This research was conducted to study the ultrasound guided adductor canal block for postoperative pain relief after total knee arthroplasty with Levobupivacaine plain versus Levobupivacaine with Dexmeditomedine. The primary objective was to assess the duration of analgesia. Secondary objectives were to assess 24 hour opioid consumption, success of early ambulation, patient satisfaction, and to look for any adverse effects or complications.

Methodology

Study design: Prospective randomised clinical study

Randomization: computer generated randomization chart

Group 1: ultrasound guided Adductor canal block with 0.25% Levobupivacaine.

Group 2: ultrasound guided Adductor canal block with 0.25 Levobupivacaine with 0.5 mcg/ml Dexmeditomedine.

Sample size and its calculation: Based on previous studies we assumed the level of significance as 0.05 and power of study as 80 percent, hence we chose each group to comprise 50 cases each after allowing for dropouts.

Inclusion criteria

1. Patients undergoing elective TKR surgeries
2. Aged between 18 and 70 years of age
3. American Society of Anesthesiologists (ASA) class 1 to 3

Exclusion criteria

1. Allergy to local anaesthetic
2. Intellectual impairment or psychiatric condition precluding adequate communication
3. Bleeding disorder, trauma and infection near the procedure area.

After informed consent 100 patients will be randomly allocated to two groups A and B to contain 50 in each group. All patients will undergo the surgery under Sub Arachnoid block with 2.5% Bupivacaine with 25mcg Fentanyl as per standard protocol. Post surgery Adductor canal block will be performed by the blinded anaesthesiologist. Opaque envelope containing patient and study group allocation will be provided to the anaesthetist performing the block. Ultrasound guided ACB will be performed as per the data in the envelope

(either 20 ml of 0.25% Levobupivacaine or 20 ml of Levobupivacaine with Dexmeditomedine will be used). Baseline HR, BP and every 15 min till 1 hour, 2nd 5th ,12th and 24 hours will be monitored. Preoperative quadriceps power will be recorded (0 to 5) and will be compared with power 6,12,24 hours after the block. Patient satisfaction will be recorded at 24 hours. Any adverse events or complications will be recorded in the 1st 24 hour period. Rescue analgesia will be provided on demand with 100mg tramadol plus 4mg ondansetron intravenously.24 hour tramadol requirement requirement will be noted. To analyse the data SPSS (Version 26.0) was used. Significance level was fixed as 5% ($\alpha = 0.05$). Qualitative variables are expressed as frequency and percentages and Quantitative variables are expressed as Mean and Standard Deviation. To compare the proportion between variables, chi-square test was used. To compare the mean values between variables, student t test and ANOVA was used.

Results

The total sample size was 100 in our study, which were divided into 2 groups. In this randomized clinical study comparing postoperative pain management in patients undergoing total knee arthroplasty, the characteristics of the study participants showed generally similar distributions in terms of age and gender across the two groups (Table 1). Patients were predominantly aged between 41 and 60 years, with a roughly equivalent percentage of males in both groups (73% in Group A and 79% in Group B). No significant differences in these demographics were noted, as indicated by high p-values. The BMI of participants was also similar across both groups, although Group A had slightly more individuals in the 18.5–24.9 range. ASA grades did, however, reveal a significant difference, with a greater number of ASA Grade I patients in Group A and more ASA Grade II patients in Group B (p=0.028, Table 1). A notable finding was the difference in surgery duration; Group A primarily had shorter procedures (55-65 minutes), while Group B had surgeries extending to 85 minutes and beyond, which was statistically significant (p<0.001, Table 1).

Analyzing the intraoperative and postoperative characteristics, Group B demonstrated a substantially delayed need of rescue analgesia compared to Group A (Table 2). In Group A, the majority of participants (50%) requested rescue analgesia at 4 hours, followed by 32% at 3 hours, and 18% at 2 hours. There were no requests recorded for 5, 6, 7, or 8 hours. In contrast, Group B exhibited a different distribution, with 46% of participants requesting rescue analgesia at 8 hours, followed by 15% at 3 hours, 12% at 4 hours, 9% at 6 hours, 8% at 7 hours, and 6% at 5 hours.

The mean ± standard deviation for Group A is 3.28 ± 0.811, suggesting that the majority of requests in this group occurred within a shorter time frame (around 3 hours). In contrast, Group B had a mean of 6.08 ± 2.133, indicating a tendency for later requests (around 6 hours). The p-value of 0.000 indicates a statistically significant difference between the two groups, implying that the timing of rescue analgesia requests significantly varied between Group A and Group B.

VAS pain scores further highlighted the difference in analgesic efficacy between the groups. Group B consistently reported lower VAS scores from the 2-hour to 12-hour marks postoperatively (Table 4). For instance, at the 2-hour interval, the mean VAS score was 1.76 in Group B versus 2.74 in Group A, with this trend continuing across subsequent intervals. These differences were statistically significant, emphasizing

the enhanced pain control offered by the combination of Levobupivacaine with Dexmedetomidine. Interestingly, at the 24-hour interval, Group B reported higher VAS scores compared to Group A (4.51 vs. 2.83, $p<0.001$, Table 4), possibly indicating a rebound effect in pain perception as the effects of Dexmedetomidine waned.

Regarding side effects, both groups experienced similar rates of hypotension and bradycardia, with no significant differences observed in these parameters. However, nausea and vomiting were entirely absent in Group B, whereas Group A had minor occurrences of these side effects, which were statistically significant ($p<0.001$, Table 5). This finding suggests that adding Dexmedetomidine may reduce nausea and vomiting risk postoperatively, possibly contributing to higher patient comfort.

Physiological stability over the postoperative period was well-maintained in both groups, as depicted in Figures 1 to 5, which showed comparable heart rate, systolic and diastolic blood pressure, SpO_2, and respiratory rate trends between the groups. This stability, combined with the prolonged analgesia and lower VAS scores in Group B, suggests that Levobupivacaine with Dexmedetomidine in adductor canal blocks may provide superior postoperative pain management without compromising safety.

Discussion

In this study, we examined the efficacy of Levobupivacaine combined with Dexmedetomidine versus Levobupivacaine alone in ultrasound-guided adductor canal blocks (ACB) for postoperative pain management in patients undergoing total knee arthroplasty (TKA). Our findings indicate that the addition of Dexmedetomidine to Levobupivacaine significantly prolongs the duration of analgesia and reduces postoperative pain scores, thereby improving patient comfort and reducing opioid consumption. These results align with existing literature suggesting that Dexmedetomidine, an alpha-2 adrenergic agonist, may enhance the analgesic effects of local anesthetics in peripheral nerve blocks.

The prolonged duration of analgesia in the Dexmedetomidine group is particularly noteworthy. The extended effect allowed patients to experience lower pain scores for a more extended period postoperatively, as evidenced by consistently lower Visual Analog Scale (VAS) scores from 2 to 12 hours after surgery. This enhancement in analgesia duration likely reflects the synergistic action between Dexmedetomidine and Levobupivacaine, where Dexmedetomidine's mechanism on central and peripheral receptors may potentiate and prolong the effects of Levobupivacaine. Previous studies have shown that Dexmedetomidine acts on alpha-2 adrenoreceptors to reduce pain signaling, which may account for its additive effect on Levobupivacaine's efficacy in this setting.

The findings also demonstrate a reduction in the need for rescue analgesia in the Dexmedetomidine group, contributing to decreased overall opioid consumption. Effective opioid-sparing strategies are critical in postoperative care, as they reduce opioid-related side effects, decrease the potential for opioid dependence, and enhance overall patient satisfaction. By reducing the immediate need for opioids, the Dexmedetomidine and Levobupivacaine combination offers a substantial clinical advantage, supporting a shift toward multimodal analgesic protocols that limit opioid use in TKA patients.

In terms of patient safety, both groups displayed comparable physiological stability, with no significant

differences in hemodynamic parameters such as heart rate, blood pressure, and respiratory rate over the monitored postoperative period. This stability indicates that Dexmedetomidine, when administered at the dosage used in this study, does not compromise cardiovascular or respiratory function, making it a viable option for enhancing analgesia in TKA patients. However, the Dexmedetomidine group experienced fewer side effects, particularly in terms of nausea and vomiting, compared to the Levobupivacaine-only group. The reduction in these side effects may further improve patient satisfaction and comfort, as nausea and vomiting can be distressing and may hinder early ambulation and recovery.

AbdelRady MM et al [10] in their study found that the mean time to first analgesic request in group L (406.77 ± 10.64 min) and group LD (515.10 ± 27.98 min, P-value <0.001). The mean total dose of morphine consumed in first 24 h postoperative was significantly lower in LD group (6.47 ± 2.01 mg) when compared to L group (10.93 ± 2.35 mg, P value <0.001). They concluded that the addition of 0.5 µg/kg dexmedetomidine to 20 mL of 0.25% levobupivacaine in single-shot ACB is better than 20 mL of 0.25% levobupivacaine alone regarding postoperative analgesia, patient satisfaction and ambulation ability following TKA but, with low rate of adverse events in both groups. This is similar to the findings of the present study.

Abo-Zeid Salim MA et al [14] in their study found that the Postoperative analgesic duration (h) was significantly longer in the ACB dex group. Karthik NM et al [15] in their study found that Dexmedetomidine is a better adjuvant in ACB block as it provides better analgesia without producing sedation, motor blockade, hemodynamic changes, or any adverse effects. Abo Elfadl GM et al [16] in their study found that that a combination of levobupivacaine and dexmedetomidine improved postoperative analgesia, increased the time to the first analgesic call, and decrease the must for postoperative analgesia. These findings are similar to the findings of the present study.

Packiasabapathy SK et al [17] in their study on Dexmedetomidine combined with Bupivacaine in TKA patients showed a significant increase in analgesia duration and a reduction in postoperative opioid use, aligning closely with our results. They also reported lower VAS pain scores in the Dexmedetomidine group compared to Bupivacaine alone, supporting the synergistic effects observed in our study.

Limitations

This study has several limitations that should be considered when interpreting the results. First, the sample size, while adequate for initial conclusions, may limit the generalizability of the findings to a broader population. A larger, multi-center study would help validate the outcomes across different patient demographics and clinical settings. Second, the study was conducted in a single tertiary care center, which may introduce bias related to specific surgical and anesthesia practices unique to this institution. Additionally, while Dexmedetomidine showed promise in extending analgesic duration, the study did not assess long-term outcomes or delayed side effects beyond the initial postoperative period, leaving a gap in understanding the potential for cumulative effects or delayed complications. Another limitation was the subjective nature of patient satisfaction measurements, which, despite being informative, could be influenced by individual patient perceptions and expectations. Finally, this study did not assess the impact of varying

Dexmedetomidine dosages on outcomes, meaning the optimal dosage for maximum benefit with minimal side effects remains to be established.

Conclusion

In conclusion, this randomized clinical study demonstrated that adding Dexmedetomidine to Levobupivacaine in ultrasound-guided adductor canal blocks (ACB) for patients undergoing total knee arthroplasty significantly enhanced the duration and quality of postoperative analgesia without compromising physiological stability. The combination of Levobupivacaine with Dexmedetomidine resulted in extended pain relief, reduced immediate opioid consumption, and contributed to greater patient comfort and satisfaction. These findings suggest that Dexmedetomidine serves as a valuable adjunct in ACB, enhancing the efficacy of Levobupivacaine and supporting earlier mobilization and improved postoperative recovery. However, further research with larger sample sizes, multi-center involvement, and varying Dexmedetomidine doses is recommended to confirm these benefits and optimize pain management protocols in total knee arthroplasty.

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Legend Tables and Figures

Table 1: Characteristics of the study participants

Characteristics of the study participants		Group A		Group B		P value
		Frequency	Percentage	Frequency	Percentage	
Age	18-30	19	19%	17	17%	0.83
	31-40	12	12%	14	14%	

	41-50	22	22%	29	29%	
	51-60	34	34%	30	30%	
	≥61	11	11%	10	10%	
Gender	Male	73	73%	79	79%	0.92
	Female	27	27%	21	21%	
BMI	<18.5	11	11%	9	9%	0.060
	18.5-24.9	58	58%	42	42%	
	25.0-29.9	27	27%	43	43%	
	≥30.0	4	4%	6	6%	
ASA Grade	I	68	68%	53	53%	0.028
	II	32	32%	47	47%	
Duration of Surgery	55-65 mins	53	53%	11	11%	<0.001
	66-75 mins	27	27%	50	50%	
	76-85 mins	20	20%	24	24%	
	> 85 mins	-	-	15	15%	

Table 2:Request of rescue analgesia (hrs)

Request of rescue analgesia (in hour)	Group 1		Group 2	
	Frequency	Percentage	Frequency	Percentage
2	18	18	4	4
3	32	32	15	15
4	50	50	12	12
5	-	-	6	6
6	-	-	9	9
7	-	-	8	8
8	-	-	46	46
Total	100	100	100	100
Mean ± Std Deviation	3.28 ± 0.811		6.08 ± 2.133	
P value	0.000			

Table 3:- Total dose of rescue analgesia (in mg)

Total dose of rescue analgesia (in mg)	Group 1		Group 2	
	Frequency	Percentage	Frequency	Percentage
50	-	-	2	2
100	-	-	39	39
150	14	14	40	40
200	11	11	19	19
250	13	13	-	-
300	8	8	-	-
350	28	28	-	-
400	26	26	-	-
Total	100	100	100	100
Mean ± Std Deviation	301.50 ± 89.178		139.5 ± 38.223	
P value	0.000			

Table 4: VAS Score by Time Interval

Time Interval (hrs)	Group 1		Group 2		P value
	MEAN	SD	MEAN	SD	
1	1.89	0.984	1.98	0.912	0.729
2	2.74	0.832	1.76	0.940	<0.001
4	3.22	1.346	2.78	0.879	0.010
6	4.42	1.760	2.72	0.742	<0.001
8	4.60	2.083	3.13	0.960	<0.001
12	4.91	1.990	3.71	1.481	<0.001
24	2.83	0.895	4.51	1.707	<0.001

Table 5: Side Effects

Side Effects	Group 1		Group 2		P VALUE
	Frequency	Percentage	Frequency	Percentage	
Hypotension	5	5.0	4	4.0	0.82
Vomiting	3	3.0	0	0.0	<0.001
Nausea	3	3.0	0	0.0	<0.001
Bradycardia	4	4.0	2	2.0	0.62

Figure 1: Post-Operative Hr

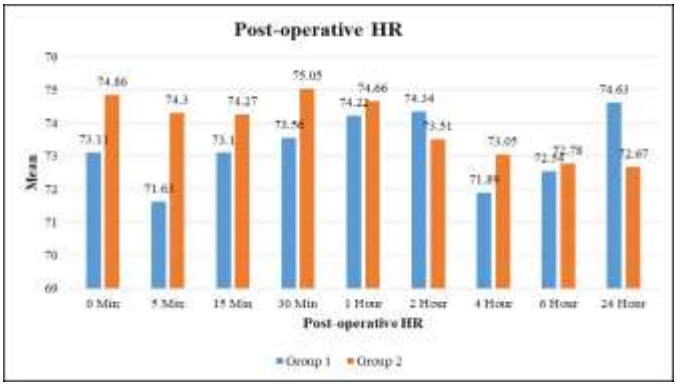

Figure 2: Post-Operative SBP

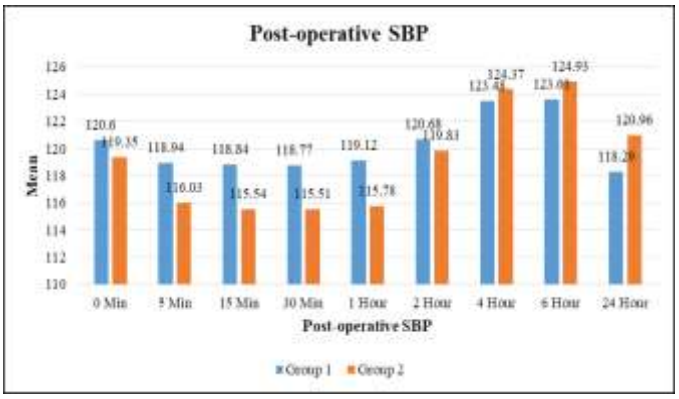

Figure 3: Post-Operative DBP

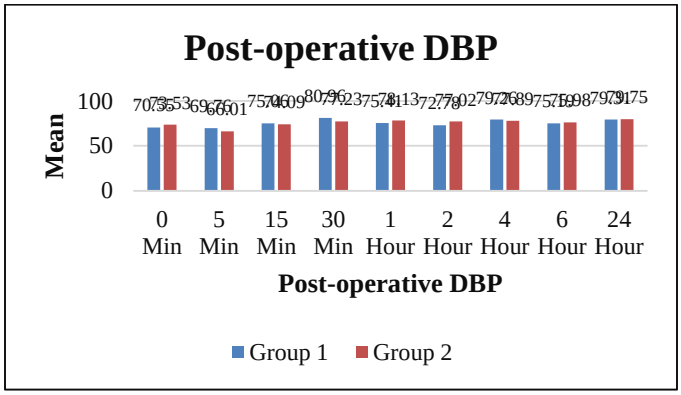

Figure 4: Post-Operative Spo2

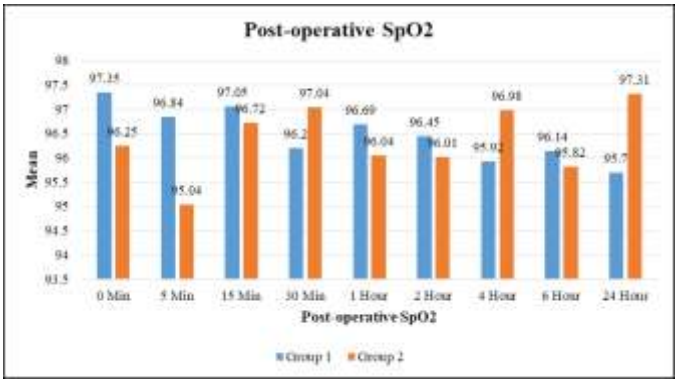

Figure 5: Post-Operative RR

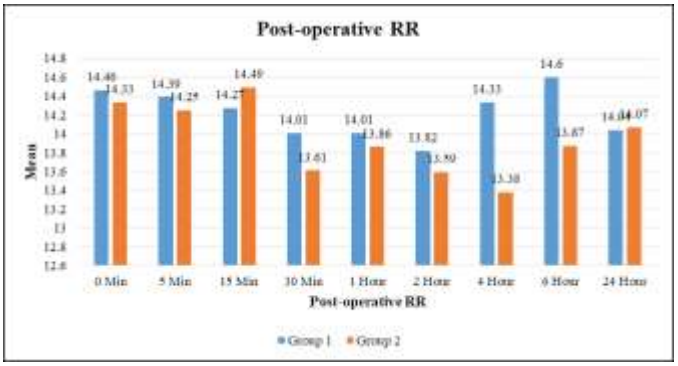

Figure 6:- Request of rescue analgesia

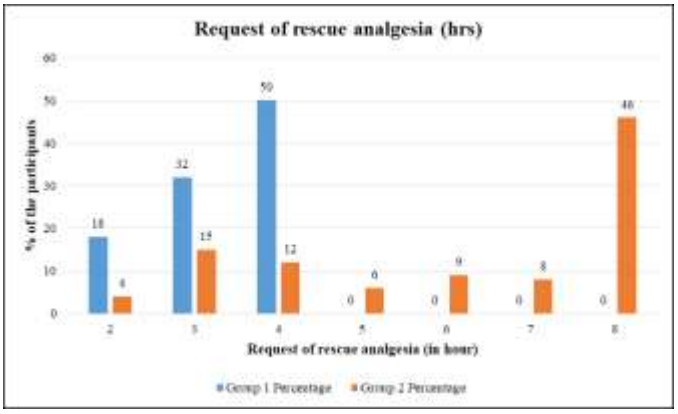

Figure 7:- Total Dose of Rescue Analgesia