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A Comparative Analysis of Complications of Intrathecal Dexmedetomidine versus Fentanyl as Adjuvants to Bupivacaine in Knee Joint Surgeries

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ABSTRACT

Background: The world is observing a rapid rise in orthopedic surgeries, and spinal anesthesia is usually the technique of choice for lower limb surgeries. Bupivacaine is generally the local anesthetic administered during these surgeries; however, adjuvants such as fentanyl and dexmedetomidine are also widely used to extend analgesia. The side effects and efficacy of such adjuvants, however, remain a topic of clinical interest. Objectives: To study the intraoperative and postoperative complications of two adjuvants, intrathecal fentanyl (25 µg), and dexmedetomidine (10 µg) for bupivacaine in patients undergoing knee joint surgeries and compare them. **Materials and methods:** A quantitative cross-sectional study was carried out on 80 patients, 40 in each group, recruited from PIMS Hospital and Allama Iqbal Teaching Hospital, Pakistan. All the patients were given spinal anesthesia, which included either intrathecal fentanyl or dexmedetomidine plus bupivacaine as an adjuvant. SPSS v22 was used for statistical analysis; one-way ANOVA was used to compare the complications, and statistical inference was drawn. **Results**: Dexmedetomidine caused prolonged sensory and motor blockade but, at the same time provided enhanced postoperative analgesia. It was also associated with a higher incidence of bradycardia and hypotension. Fentanyl increased the incidence of nausea and/or vomiting. Overall, once again, dexmedetomidine came out to be better of the two in terms of complications which were less in number and less severe, besides providing its usual strong analgesic effects. **Conclusion:** Intrathecal dexmedetomidine (10 µg) leads to better and longer analgesia with less complications, compared to fentanyl (25 µg), as an adjuvant to bupivacaine, hence providing a viable alternative for knee joint surgeries in terms of safety.

Keywords: Orthopedic Surgery, Spinal Anesthesia, Dexmedetomidine, Fentanyl, Bupivacaine. postoperative pain, knee surgery

INTRODUCTION

Orthopedic surgery is one of the surgical subspecialties with the quickest rate of growth in the globe. It is anticipated to increase by 4.9% a year to an estimated 22.3 million orthopedic procedures performed globally in 2017. By 2022, there will be 28.3 million operations [1]. Orthopedic operations can be performed under either general or regional anesthesia, but during the past few decades, regional anesthetic has grown in popularity for many of these procedures. The oldest and most widely used kind of

regional anesthesia is spinal anesthesia. In order to temporarily stop nerve impulse conduction in the spinal nerve roots, a local anesthetic is injected into the subarachnoid space. Orthopedic surgery, specifically hip, knee, and ankle surgery, makes extensive use of it [2].

The observation revealed that in the recent few decades some of the surgical procedures for instance open reduction procedures and internal fixation of the fractures as well as arthroscopies and arthroplasties have become very popular amongst Orthopedic Surgeons, due to their outstanding success and track record[3, 4]. This study included the patients undergoing knee joint surgeries because of its less complexity and number of complications as well as prolong duration [1]. The incidence of postoperative pain in orthopedic surgeries in the first 24h was 70.5% [5, 6]. Orthopedic surgery, especially total joint replacement, results in moderate to severe pain in a majority of patients. Improvements in pain management have been amongst the most substantial advancements in the practice of total joint replacement surgery [7]. Inadequately controlled pain adversely affects quality of life and its functions, and recovery, additionally increases the risk of postoperative complications and the risk of persistent post-surgical pain. Appropriate treatment of pain in these patients promotes healing, shortens length of recovery, and improves quality of life after surgery. Pain has become the "fifth vital sign" in the view of the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and demands consideration in the care of all patients [7]. Different trials have shown that multimodal technique with different drugs is very effective in pain relief. In this article the complications of two drugs Fentanyl and Dexmedetomidine, as an adjuvant with Intrathecal Bupivacaine, used for pain management was compared. Opioids were the first group of drugs to be used along with bupivacaine. Opioids are the main class of medications used for ain management, antitussive, and antidiarrheal effects. They primarily function within the central nervous system (CNS) to deliver these therapeutic benefits, such as pain alleviation, sedation, and cough cessation. Three distinct types of opioid receptors—delta (δ), kappa (κ), and mu (μ)—have been identified [8]. Opioids produce dose-dependent sedation when taken by themselves; when combined with other sedatives, this duration of sedation increases. Although they extend the analgesic duration, they cause side-effects such as nausea, vomiting, sedation, and respiratory depression. Fentanyl is an agonist of lipophilic μ-receptor that produces analgesia as a result of its action at a supraspinal level on specific opioid receptors in the dorsal horn of the spinal cord [4]. In a range of clinical settings for perioperative pain management, including ambulatory surgery, obstetric procedures (such as cesarean section), and gynecological and weight-bearing joint surgery, intrathecal fentanyl is used extensively [9]. Dexmedetomidine, being used for spinal anesthesia, an α2 agonist, is also used for prolongation of sensory and motor blockade. Buprenorphine blocks C-fiber input by binding to the neurons of dorsal horn, thereby inhibiting C-fiber neurotransmitter release and inducing hyperpolarization at the postsynaptic membrane, contributing to its pain-relieving ability [10]. Dexmedetomidine acts within the subarachnoid space and at both spinal and supraspinal levels. At spinal levels, it stimulates α2adrenergic receptors, inhibiting the transmission of the pain signal and limiting the release of substance P to provide an opioid-sparing effect. At supraspinal levels, it stimulates α2adrenergic receptors on presynaptic neurons in the locus coeruleus and functions as an anxiolytic and sedative. The postsynaptic activity in the central nervous system inhibits sympathetic outflow, reducing blood pressure and heart rate [11].

Zagazig University Hospitals conducted a double-blind, prospective randomized controlled study in which 45 patients undergoing knee arthroscopy were given intraarticular bupivacaine along with dexmedetomidine and fentanyl. Bupivacaine alone, bupivacaine with dexmedetomidine, or bupivacaine plus fentanyl were administered to randomly selected patients. Fentanyl (50 μg) generated a longer duration of analgesia (693.3 ± 22.6 minutes) and required less rescue analgesia than both dexmedetomidine and controls. Patients who received either adjuvant reported feeling reduced pain. There were no discernible therapy-related adverse effects from any adjuvant. Fentanyl is essentially a safe and efficient adjuvant that may prolong post-operative pain management for patients undergoing knee arthroscopy [12]. Subsequent studies investigated the effectiveness of fentanyl and dexmedetomidine as adjuncts to intrathecal bupivacaine in reducing POUR following knee arthroscopy. In a study conducted by Ain Shams University hospitals with 70 patients, the incidence of POUR was 28.6% in the fentanyl group and 5.7% in the dexmedetomidine group. Dexmedetomidine-using patients required more postoperative urine catheterization, had a longer motor block, and a faster maximum block time. According to the study, intrathecal dexmedetomidine may be used as a suitable supplement in circumstances requiring more anesthetic due to its extended duration. fentanyl, which was linked to less urine retention, in contrast to sensory and motor blockade [13].

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A study of 240 patients who underwent elective cesarean deliveries at CMH Rawalpindi from 2021 to 2023 examined the effects of adding dexmedetomidine (5 mcg) and fentanyl (25 mcg) to levobupivacaine. Although dexmedetomidine was shown to have prolonged blockade, it also caused increased hypotension, shivering, nausea, and vomiting, as well as a delayed beginning of blocking [14]. Despite the negative effects, dexmedetomidine demonstrated improved hemodynamic stability and duration, which makes it a reasonable alternative to fentanyl [3]. AF Omara and colleagues (2023) separated a sample of 105 patients who had undergone complete knee replacement surgery for assessment. into morphine to three groups: dexmedetomidine, morphine–dexmedetomidine, and a control group. Higher pain scores, earlier rescue analgesic administration, and lower levels of sedation were observed in the dexmedetomidine group. Compared to the dexmedetomidine group, the morphine group suffered more nausea and vomiting. There were no significant differences for the combination [11]. Researchers were able to evaluate the effects of substituting intrathecal hyperbaric bupivacaine with either 25 micrograms of fentanyl or 5 µg dexmedetomidine in a double-blind randomized study involving 150 patients scheduled for elective lower abdominal surgery [15]. Both adjuvants significantly increased the duration of analgesia and motor block, produced a quicker onset of the block, and demonstrated higher sedation ratings when compared to bupivacaine or hyperbaric bupivacaine alone. In the end, dexmedetomidine and bupivacaine produced a rapid onset and long-lasting sensory and motor block with favorable sedative effects, and they might be a better analgesic option for lower abdominal procedures. As an adjuvant to 2.5 mL hyperbaric bupivacaine, fentanyl (25 µg) and dexmedetomidine (10 µg) were compared in a randomized study involving 54 patients undergoing lower limb procedures under spinal anesthesia. Sensory and motor block durations were significantly greater in the dexmedetomidine group, and the time to first rescue analgesia was likewise longer (409.6). Fentanyl: ± 74.6 min vs. 295.9 ± 36.7 min, with few adverse effects. The authors observed that, for protracted and improved postoperative analgesia, intrathecal dexmedetomidine is superior than fentanyl [16]. Ninety patients undergoing knee arthroscopy participated in a randomized study that examined the impact of intrathecal and intravenous dexmedetomidine on the properties of spinal anesthesia with ropivacaine. Compared to the intravenous and control groups, intrathecal dexmedetomidine significantly prolonged total analgesia (352.1 ± 51.7 min) and provided a faster onset of sensory and motor block. It also decreased postoperative pain levels and had no significant side effects. While intrathecal dexmedetomidine produced more sustained and long-lasting analgesia without compromising hemodynamics, intravenous dexmedetomidine significantly increased bradycardia and sedation in the two groups [17].

MATERIALS AND METHODS

It was a cross-sectional quantitative study based on convenient sampling technique. The population size included 80 patients of either gender undergoing spinal anaesthesia for knee joint surgeries. Patients were divided into two groups i.e. Each group having 40 patients, one with fentanyl (25mcg) as an adjuvant while other with dexmedetomidine (10mcg). The amount of dosage used in this study is consistent with previously established research[18, 19]. Data was collected from PIMS Hospital, Islamabad and Allama Iqbal Teaching Hospital, Dera Ghazi Khan. The data was collected on a pre-structured Performa by observing the complications intra and post-operatively. Frequency and percentages were calculated and data was compared using one-way ANOVA through SPSS version 22.

RESULTS

The study included 80 individuals. The majority (38.8%, n=31) were between the ages of 41 and 50, with a somewhat lower number falling into the 31–40 age group (12.5%) and the 51–60 age group (32.5%). A lower proportion of people were between the ages of 21 and 30 (2.5%) or 61 and 70 (13.8%). Overall, the gender demographics show that men made up the majority of participants. Of those who participated in the study, 61.3% were men and 38.8% were women. Only 18.8% of participants were classified as ASA III, indicating that they had a substantial systemic condition that affected and limited their movement, whereas a far higher percentage (81.3%) were classified as ASA II, indicating that they had a minor systemic ailment. The participants were primarily older persons with mild to moderate health issues, according to the overall demographics (Table 1).

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Table 1. Demographic Analysis (N=80)

	Categories	Frequency	Percent
Age	21-30 years	2	2.5%
	31-40 years	10	12.5%
	41-50 years	31	38.8%
	51-60 years	26	32.5%
	61-70 years	11	13.8%
Gender	Female	31	38.8%
	Male	49	61.3%
Grading	ASA II	65	81.3%
	ASA III	15	18.8%

Figure .1 represents the distribution of participants across different Body Mass Index (BMI) groups is shown in the bar graph. The majority of participants (60%, n=48) are overweight, while the largest group (37.5%, n=30) is classed as normal weight. Obese Class I (1%), and Underweight (1.25%) have the lowest percentages. Generally speaking, it is evident that the vast majority of participants fall into the category of being overweight, with overweight being the largest group.

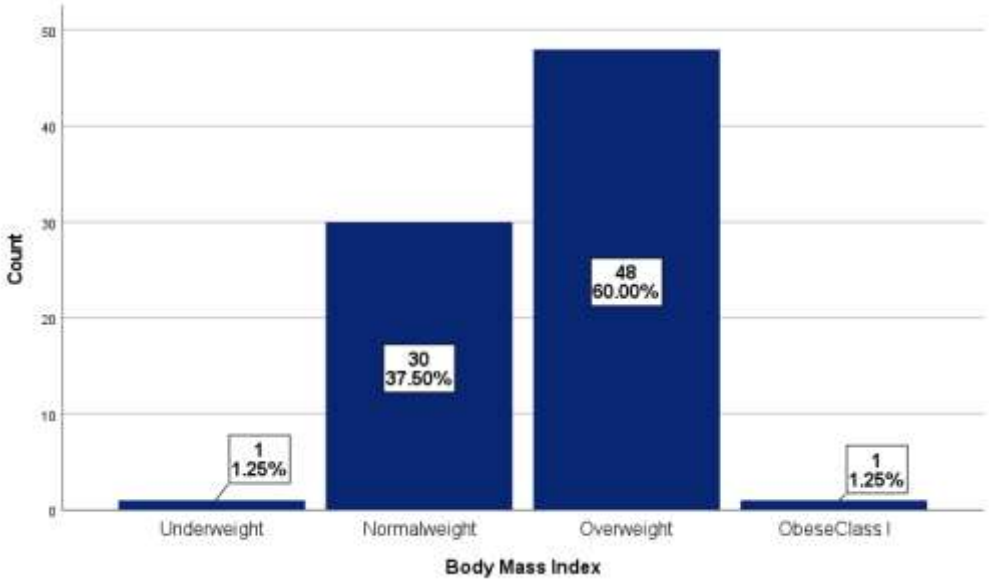

Figure1. Distribution of Participants on Base of Weight.

The pie chart below illustrates the distribution of patients in relation to the type of knee surgery (figure 2). The two most preferred surgeries were Partial Knee Replacement and Total Knee Replacement, each showing a tremendous 36.25% (29 patients) share. Then, Knee Arthroscopy was performed in 10% (8 patients) cases, mostly for less invasive surgeries, while Knee Arthroplasty was the next most frequent, with 15% (12 patients), which denotes its regular intervention in surgical management of the knee. On the contrary, Knee Osteotomy was the rarest surgical procedure, with just 2.5% (2 patients), which therefore indicates that it is only done under very particular circumstances. In summary, data indicate that knee replacement operations were the main surgical modality for the treatment of knee joint disorders within this patient group.

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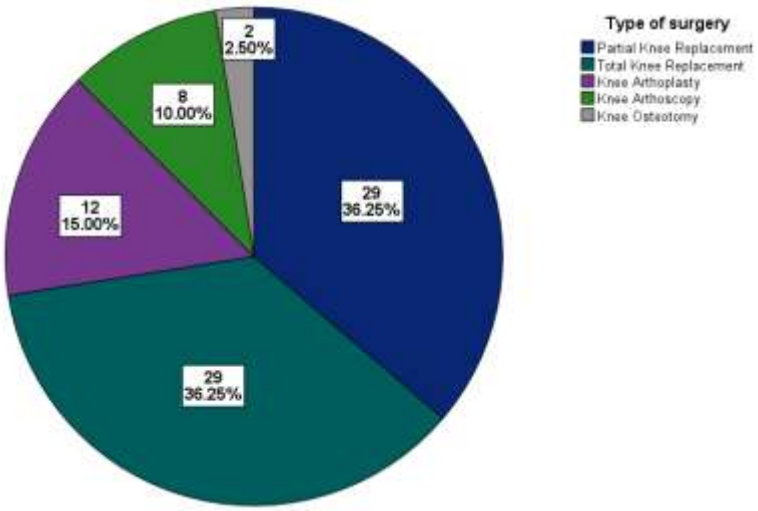

Figure2 Types of Surgeries

COMPLICATIONS

Eighty patients were divided into two groups, one of which received dexmedetomidine and the other fentanyl. Along with recording the usual adverse effects linked to each drug, the goal was to record and compare the complications that arose during the procedure and afterward.

Intraoperative complications

The intraoperative complication rates are compared with two cases because Table 2 compares two groups of patients who received IN fentanyl (25 mcg) in one group and in dexmedetomidine (10 mcg) in the other group. The "asymptotic significance" values in Table 2 reveal that some complications differ from one another among the study's two comparator groups. Bradycardia and tachycardia with hypotension were significantly higher among patients on dexmedetomidine ($p<0.001$). On the contrary, nausea and vomiting were statistically higher in fentanyl users. The current study includes patients with blood loss, but the exact volume of blood loss is not mentioned, which puts patient safety at risk. Overall, this study's findings suggest that dexmedetomidine may have a different risk profile for perioperative complications compared to fentanyl.

Table 2: Comparison of Intra-operative Complications

Intra-operative Complications	Adjuvant		Total	Asymptotic Significance
	Intrathecal Fentanyl (25mcg)	Intrathecal Dexmedetomidine (10mcg)		Pearson Chi-Square
Nausea and Vomiting	1	0	1	
BL[1]+Nausea and Vomiting	11	0	11	
Hypotension+Nausea and Vomiting	4	0	4	
Nausea...+BL+Hypotension	11	0	11	
Brady/Tachycardia+Hypotension	0	25	25	<.001
Brady/Tachycardia+Nausea...	5	0	5	
Brady/Tachycardia+BL+Hypotension	0	1	1	
Brady/Tachycardia+Hypotension+ Nausea…	1	7	8	
ALL[2]	7	7	14	
Total	40	40	80	

[1]*BL (Blood Loss),* [2]*ALL (Nausea & vomiting + BL + Hypotension + Brady/Tachycardia)*

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Post-Surgical Complications

Postoperative complications of patients who received intrathecal fentanyl (25 mcg) or intrathecal dexmedetomidine (10 mcg) postoperatively are reported in Table 3. Individual side effects of headache, chills, and the combination of these with pain and urine retention were higher in the dexmedetomidine group compared to that of fentanyl. More importantly, the "ALL" category for complications should be interpreted cautiously because the p value of <.001 means that the participants in the group receiving dexmedetomidine had fewer overall complications. More specifically, patients who received intrathecal fentanyl had more significant events combined with fewer postoperative complications. Overall, these results demonstrate varying trends in postoperative complications with the use of these adjuncts.

DISCUSSION

This cross-sectional study is based on the comparison of complications between Intrathecal fentanyl and dexmedetomidine as an adjuvant in knee joint surgeries with Bupivacaine which was analyzed in detail by marking the intra-operative and post-operative complications separately. The above concluded results showed that Dexmedetomidine provides better response with less pain and complications. This study also discussed intraoperative and postoperative risk posed using dexmedetomidine and fentanyl as adjuvants to bupivacaine. The number of challenges exhibited enormous variation. The research such as Safaa et al. are therefore likely to be faced with these huge variations because of small sample size and different inclusion criteria based on ASA grading *Safaa et.al* (2023)[18]. The reports supporting present findings would not do any testing thus conflicting with theirs [16, 20]. This study, however, found that fewer and less severe complications had occurred in patients receiving intrathecal dexmedetomidine, in agreement with some past work [21]. Other studies have extensively begun looking into these systems as attested by published work, to yield better results among patients that administered with Dexmedetomidine (Group D) [10, 22].

Table 3 Comparison of Post-operative Complications

Post-operative Complications	Adjuvant		Total	p-value
	Intrathecal Fentanyl (25mcg)	Intrathecal Dexmedetomidine (10mcg)		
Nil	0	1	1	
Headache	0	5	5	
Headache+Pain	1	11	12	
Shivering	0	2	2	
Shivering+Headache	1	6	7	
Shivering+Headache+Pain	29	9	38	<.001
Headache+Urinary Retention	0	1	1	
Headache+Pain+Urinary Retention	1	3	4	
Headache+Shivering+ Urinary Retention	0	1	1	
ALL[1]	8	1	9	
Total	40	40	80	

[1]*ALL (Headache + Pain + Shivering + Urinary Retention)*

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FUTURE DIRECTION

Intraoperative and postoperative extensive hemodynamic monitoring with management of side effects for patient safety are required during and after the procedure. An important recommendation is to repeat a similar study on a larger heterogeneous size sample considering multiple hospitals as this study was based on only two hospitals, that would further substantiate the results above while assessing the long-term effects of medication in varied groups of patients. Professionals and students taking specialization in Anesthesia should be properly trained in the use of dexmedetomidine in order to discourage its misuse and improve patient Outcome. Comparative study on these drugs in patients of age <18 years and >60 years can be considered for future studies.

CONCLUSION

From this study, one can borrow a conclusion that intrathecal dexmedetomidine (10 mcg) as an adjuvant with bupivacaine gave a superior sensory and motor block with improved post-operative pain control in knee joint surgical procedures than did intrathecal fentanyl (25 mcg). The study compared the intraoperative and postoperative complications between the groups. The dexmedetomidine group had lesser intraoperative complications and were less severe. A systematic review of all published studies beyond doubt confirmed intrathecal dexmedetomidine (10 mcg) combined with bupivacaine is more suitable than fentanyl (25 mcg) for knee joint surgeries.

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

AUTHOR CONTRIBUTION

All the Authors contributed in planning and the collection of data, drafting manuscript and analyzing data to be qualified for Authorships.

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