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ORIGINAL ARTICLE

Comparative Study of Bupivacaine-Dexmeditomidine and Bupivacaine-Fentanyl with Bupivacaine Plain as Local Infiltration for Postoperative Analgesia After Abdominal Hysterectomy Under Subarachnoid Block

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Abstract

Introduction: Abdominal hysterectomy is a common surgical procedure associated with significant postoperative pain. Effective pain management is crucial to enhance recovery and reduce opioid dependency. Multimodal analgesia, including local wound infiltration with adjuvants, has been explored to optimize pain control. This study compares the efficacy of bupivacaine alone, bupivacaine with fentanyl, and bupivacaine with dexmedetomidine for postoperative analgesia in patients undergoing abdominal hysterectomy. **Materials and Methods:** This hospital-based observational study was conducted at MES Medical College over one year. A total of 81 patients undergoing elective abdominal hysterectomy under subarachnoid block were randomly allocated into three groups: Group B (20 ml of 0.25% bupivacaine), Group F (20 ml of 0.25% bupivacaine with 20 mcg fentanyl), and Group D (20 ml of 0.25% bupivacaine with 20 mcg dexmedetomidine). Postoperatively, hemodynamic parameters, pain scores using the Numeric Rating Scale (NRS), time to first rescue analgesia, and total rescue analgesic consumption were assessed over 24 hours. SPSS 15 was used for statistical analysis. A p value < 0.05 was considered as significant. **Results:** Among the groups, demographic characteristics and duration of surgery were comparable. Group D demonstrated a significantly prolonged duration of analgesia (5.4 ± 1.2 hours) compared to Group F (3.1 ± 1.1 hours) and Group B (2.6 ± 1.3 hours) ($p < 0.001$). The time to first rescue analgesia was longest in Group D (7.6 ± 1.5 hours) ($p < 0.001$). Total rescue analgesic consumption was lowest in Group D, followed by Group F, and highest in Group B ($p < 0.001$). Adverse effects were minimal across all groups. Hemodynamic stability was also seen among all groups. **Conclusion:** The addition of dexmedetomidine to bupivacaine for local wound infiltration provides superior postoperative analgesia compared to fentanyl or bupivacaine alone, with a significantly prolonged analgesic duration and reduced need for rescue analgesics. Dexmedetomidine is a promising adjuvant for improving postoperative pain management in abdominal hysterectomy.

Keywords: Postoperative analgesia, bupivacaine, dexmedetomidine, fentanyl, abdominal hysterectomy

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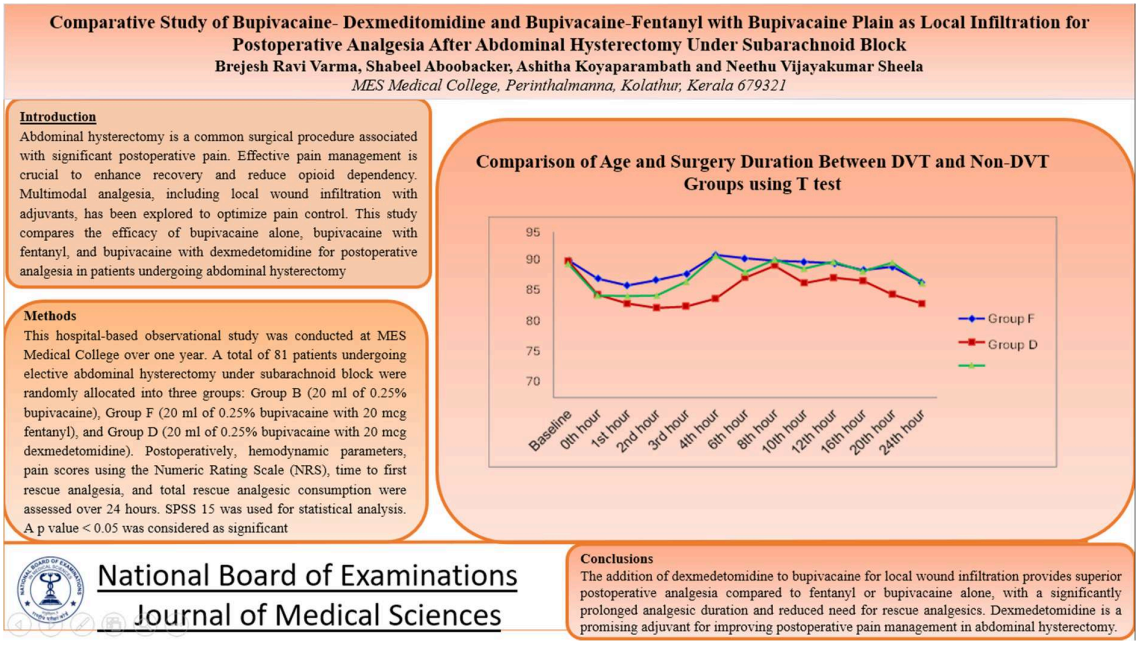
Graphical Abstract



Introduction

Abdominal hysterectomy is the second most common surgery in females after caesarean section [1]. Surgical removal of the uterus, along with the fallopian tubes, ovaries, and cervix, is a widely accepted treatment for uterine malignancies and various common non-malignant uterine conditions, including abnormal uterine bleeding, fibroid uterus, vaginal prolapse, and adnexal masses [2]. The aetiology of pain following abdominal surgery is multifactorial, encompassing abdominal wall damage, visceral trauma, inflammation, and peritoneal irritation. The somatic innervation of the anterior abdominal wall originates from T6–L1, while the skin below the umbilicus derives its innervation from T11–L1. The peritoneum is a metabolically active organ that responds to surgical insult with both local and systemic inflammatory responses. Peritoneal nociceptors, which become activated due to surgical injury and intraperitoneal inflammation, contribute significantly to visceral pain [3]. The abdominal incision can cause moderate to severe pain, especially in the immediate postoperative period, and its intensity varies among individuals. Postoperative pain generally lasts up to 48 hours [4]. Acute postoperative pain after abdominal surgeries can increase morbidity, leading to restricted breathing efforts, inadequate coughing, secretion retention, reduced functional residual capacity, early airway closure, and even segmental or lobar collapse [5].

The prevalence of acute postoperative pain varies widely. Reported global prevalence ranges from 14% to 70%, depending on pain intensity, type of surgery, and anesthesia used. One study documented postoperative pain prevalence following abdominal surgeries as 84.17%, 92.5%, and 66% on days 1, 2, and 3, respectively [6] which is overwhelmingly high.

Multimodal analgesia (MMA) involves the combination of different classes of medications with varying pharmacological mechanisms, leading to

additive or synergistic effects to alleviate postoperative pain and its sequelae. Regional analgesic techniques are one of the most important components of multimodal pan management. It includes local anesthetic wound infusion, epidural or intrathecal analgesia (single-shot or continuous), and peripheral nerve blockade. Of the above, wound infusion has emerged as an effective approach for improving postoperative pain and reducing the need for intravenous or oral opioids, especially in patients undergoing open abdominal surgeries. Local anaesthetic infiltration is a simple, safe, cost-effective, and widely used method for postoperative analgesia. Adjuvants like Non-Steroidal Anti-Inflammatory Drugs (NSAIDs), Dexmedetomidine, Clonidine, Epinephrine, Opioids, Steroids, Ketorolac, and Magnesium sulphate, can be added to local anesthetic agents to improve the quality and duration of analgesia. Commonly used local anesthetics for infiltration anesthesia include 0.5–1.5% Lignocaine, 0.125–0.5% Bupivacaine, and 0.2–0.5% Ropivacaine [7]. Dexmedetomidine is an alpha-2 adrenoreceptor agonist. It produces analgesia by reducing norepinephrine release and by exerting an alpha-2 receptor-independent inhibitory effect on nerve fibre action potentials [8]. Fentanyl is a synthetic μ-opioid agonist with minimal histamine-releasing properties and is considered a superior drug for peripheral analgesia [9].

This study aims to compare the duration of post operative analgesia after local bupivacaine –fentanyl infiltration and bupivacaine – dexmedetomidine to plain bupivacaine. This study also assesses the severity of pain among the three groups. The study is done to also evaluate the postoperative requirements of intravenous rescue analgesics (NSAIDs/Opioids). As the impact of postoperative pain on recovery and overall patient well-being is high, identifying an optimal analgesic technique that provides prolonged pain relief while minimizing opioid dependence is crucial. This study is important as to explore effective pain management strategies. Thereby enhancing patient comfort, reducing complications, and improving postoperative outcomes.

Materials and Methods

This was a hospital based observational study conducted at MES Medical College. This study was done among patients undergoing elective abdominal hysterectomy under subarachnoid block. After obtaining Institutional Human Ethics Committee approval, the study was conducted over a period of one year. Written informed consent was obtained from all participants before start of the study. Patients were recruited based on defined inclusion and exclusion criteria.

Patients were divided into three groups depending on the wound infiltration technique used postoperatively. Group B received 20 ml of 0.25% bupivacaine, Group F received 20 ml of 0.25% bupivacaine with 20 mcg fentanyl (0.4 ml), and Group D received 20 ml of 0.25% bupivacaine with 20 mcg dexmedetomidine. The study included patients aged 35 to 60 years with ASA grades I and II who voluntarily participated. Patients with a history of opioid or substance abuse, failed spinal anesthesia, prolonged surgeries exceeding three hours, difficulty in pain assessment, height below 150 cm, BMI over 30 kg/m², or hypersensitivity to local anesthetics,

dexmedetomidine, fentanyl, NSAIDs, or opioids were excluded.

The minimum sample size required for the study was determined using a sample size estimation formula from a similar previous study by Swathi Singh et al. A total of 81 patients meeting the inclusion criteria were selected using a non-probability convenience sampling technique, with consecutive patients being enrolled until the target sample size was reached.

Pre-anesthetic evaluation was conducted a day prior to surgery, during which patients were educated about the Numeric Rating Scale (NRS) for pain assessment. On the day of surgery, patients were secured with an 18G intravenous cannula and started on IV fluids. Anti-aspiration prophylaxis (IV pantoprazole and IV metoclopramide) and prophylactic antibiotics (IV cefotaxime) were administered. Blood was cross matched, and arrangements were made for transfusion if necessary. In the operating room, standard ASA monitors, including pulse oximetry, non-invasive blood pressure, and ECG, were attached, and baseline vitals were recorded. Spinal anesthesia was administered using 3 ml of 0.5% heavy bupivacaine at the L3-L4 interspace with a 25G Quincke's spinal needle. All patients received IV paracetamol 1g preoperatively and postoperatively every six hours.

At the end of surgery, the respective wound infiltration drug combinations were administered along the surgical wound as decided by the anaesthesiologist in that operating room following the departmental protocols. Postoperatively, patients were monitored in the recovery room and subsequently in the ward for 24 hours. Hemodynamic parameters, including heart rate, blood pressure, respiratory rate, oxygen saturation, and pain scores, were recorded at 0 hours, every hour for the first four hours, every two hours for the next 12 hours, and every four hours thereafter. The duration of analgesia was defined as the time from local infiltration to the first reported pain requiring rescue analgesia. Severity of pain was assessed using NRS, and the time to the first rescue analgesic dose, frequency of further doses, and additional analgesic requirements were noted. The observations were made by an independent observer who was blinded to the selection of infiltration drug combination used in that particular subject.

Rescue analgesia was administered when NRS was equal to or greater than 4. Diclofenac sodium 75 mg IV diluted in 100 ml normal saline was given as the first-line rescue analgesic over 15 minutes. If analgesia was still inadequate, IV tramadol 50 mg diluted in 100 ml normal saline was administered over 10 minutes.
Data were recorded using a structured proforma and analysed using SPSS version 15. Quantitative data were expressed as means and standard deviations. The statistical significance of analgesic requirements was determined using one-way analysis of variance (ANOVA), with a p-value of <0.05 considered statistically significant

Results

The demographic characteristics, including age, height, weight, and BMI, were comparable across Groups F, D, and B, with no statistically significant differences ($p > 0.05$). Similarly, the duration of surgery did not differ significantly among the groups ($p = 0.206$). There was no significant difference

between the groups with respect to ASA classification. However, significant differences were observed in pain-related parameters. The time of onset of pain was longest in Group D (5.4 ± 1.2 hours) compared to Group F (3.1 ± 1.1 hours) and Group B (2.6 ± 1.3 hours), with a highly significant difference ($p < 0.001$). The time to first rescue analgesic was also significantly longer in Group D (7.6 ± 1.5 hours) compared to Group F (4.5 ± 1.8 hours) and Group B (3.4 ± 1.2 hours) ($p < 0.001$). Subsequent rescue analgesic time intervals followed a similar trend, being longest in Group D (10.9 ± 6.6 hours) compared to Group F (9.2 ± 2.2 hours) and Group B (6.2 ± 2.3 hours), showing statistical significance ($p < 0.001$). The total number of rescue doses was lowest in Group D (1.9 ± 0.6) compared to Group F (3.7 ± 1.1) and Group B (4.7 ± 0.7), again indicating a significant difference ($p < 0.001$). Additionally, the interval between the first and second dose was longest in Group D (5.4 ± 3.4 hours) followed by Group F (4.7 ± 1.2 hours) and shortest in Group B (2.9 ± 1.4 hours), with statistical significance ($p < 0.001$). These findings suggest that Group D demonstrated the most prolonged analgesic effect with a reduced need for rescue analgesia, while Group B required the highest number of rescue doses with the shortest analgesic duration (Table 1).

Table 1. Comparative Analysis of Analgesic Efficacy and Rescue Analgesia Requirements Among Groups F, D, and B

	Group F (n=27)		Group D (n=27)		Group B (n=27)		p
	mean	SD	mean	SD	mean	SD	
AGE	45.8	3.9	43.0	9.1	46.1	7.1	0.247
HEIGHT (cm)	161.1	8.2	162.0	8.0	163.1	7.3	0.667
WEIGHT (kg)	62.6	13.5	63.5	10.9	64.0	10.0	0.910
BMI (kg/m^2)	23.7	3.6	24.1	2.3	24.0	2.2	0.887
Duration of Surgery	1.3	0.3	1.2	0.2	1.2	0.2	0.206
Time of onset of pain (in hours)	3.1	1.1	5.4	1.2	2.6	1.3	<0.001
Time of first rescue analgesic (in hours)	4.5	1.8	7.6	1.5	3.4	1.2	<0.001
Subsequent	9.2	2.2	10.9	6.6	6.2	2.3	<0.001
Total number of rescue doses	3.7	1.1	1.9	0.6	4.7	0.7	<0.001
Interval between 1st and 2nd Dose	4.7	1.2	5.4	3.4	2.9	1.4	<0.001

Significant differences in heart rate were observed at the 3rd, 4th, 20th, and 24th hours post local infiltration, with Group D showing consistently lower mean heart rates at these time points compared to Group F and Group B. Additionally, Group B exhibited a trend of lower heart rates over 24 hours compared to baseline values, while Group D showed the most pronounced decline, indicating a possible sustained bradycardic effect in this group (Figure 1).

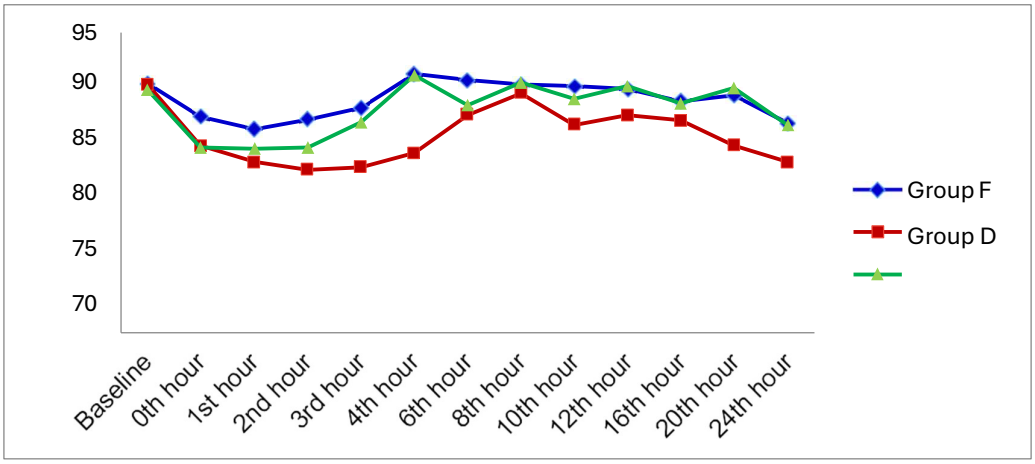


Figure 1. Heart Rate

While there were no major overall changes in respiratory rate across the 24-hour period, statistically significant differences were observed at the 4th, 8th, 20th, and 24th hours. Group B exhibited higher respiratory rates at the 4th and 8th hours compared to the other groups, while Group D tended to have slightly lower values, suggesting potential differences in respiratory response among the groups (Figure 2).

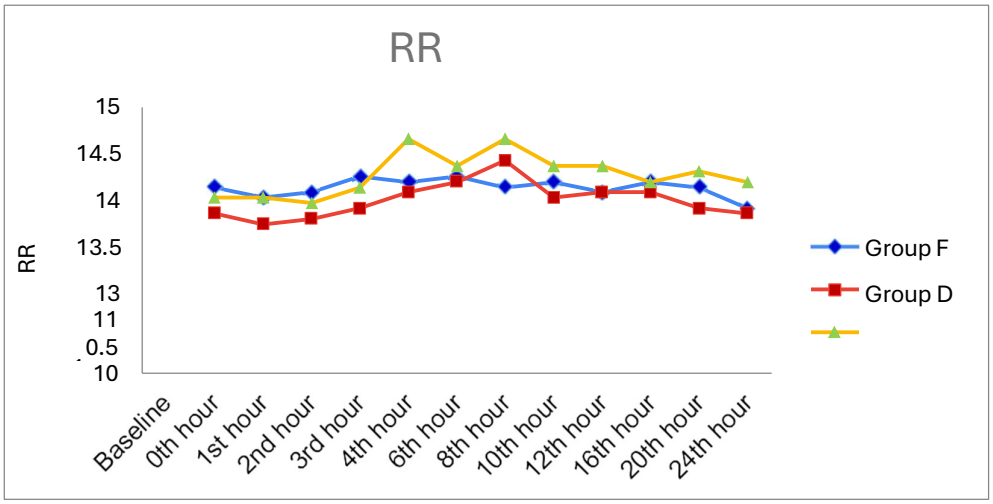


Figure 2. Respiratory Rate

There were no significant differences in SpO2 levels among the three groups at any time point during the 24-hour period. This indicates that despite variations in other haemodynamic parameters, oxygen saturation remained stable across all groups, suggesting adequate respiratory function and oxygenation in all patients (Figure 3).

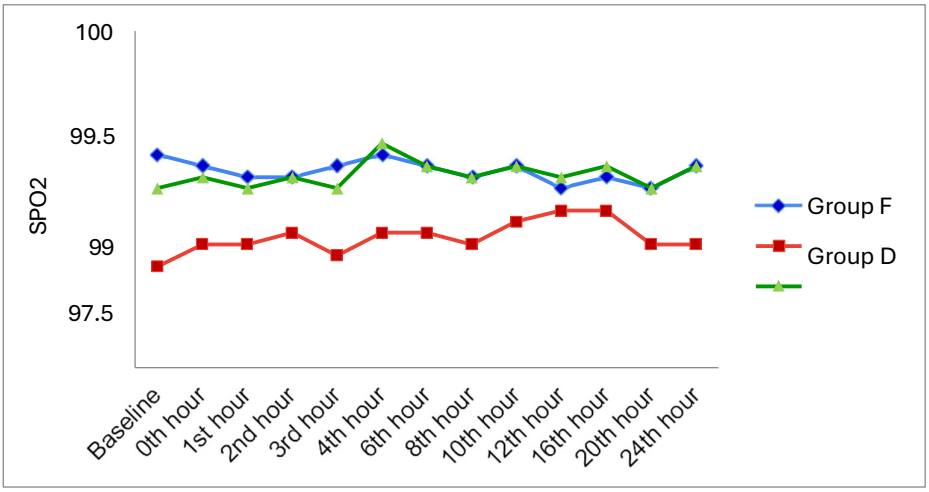


Figure 3. SPO2

Systolic Blood Pressure (SBP) were significantly lower as was noted at the 4th, 6th, 20th, and 24th hours post infiltration, particularly in Group D, which consistently exhibited the lowest mean SBP values at these intervals. Despite these differences, all groups showed an overall trend of lower SBP compared to baseline, suggesting a lesser sympathetic response induced rise in SBP, due to improved pain relief following local infiltration, with Group D experiencing the most pronounced decline (Figure 4).

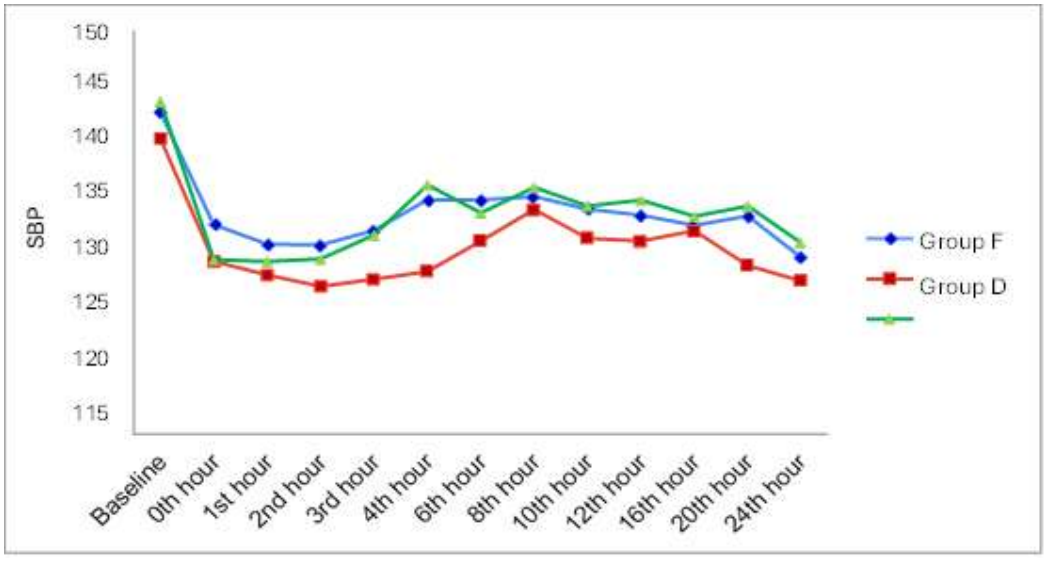


Figure 4. Comparison of SBP at different intervals

Significant changes in Diastolic Blood Pressure (DBP) were observed at multiple intervals, specifically at the 1st, 3rd, 4th, 6th, 12th, 16th, 20th, and 24th hours. Group D consistently demonstrated lower DBP values than the other groups, with the most pronounced differences at the 3rd and 4th hours. This suggests a more substantial reduction in vascular resistance and better blood pressure regulation in Group D compared to Groups F and B (Figure 5).

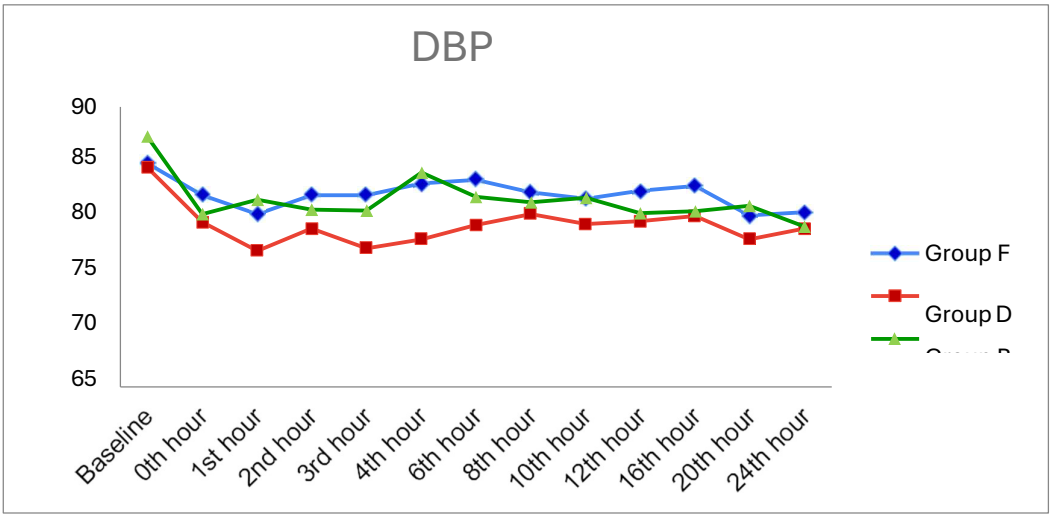


Figure 5. Comparison of DBP at Different Intervals of Time

Discussion

Abdominal hysterectomy with or without salpingo-oophorectomy is associated with moderate to severe postoperative pain, which is most intense during the first 48 hours. Surgical incision initiates an acute inflammatory response, triggering cytokine release that stimulates nociceptors and enhances pain perception. Suboptimal postoperative pain management can lead to complications such as increased morbidity, anxiety, impaired physical activity, prolonged hospitalization, and increased healthcare costs [10]. Multimodal analgesia, which combines different analgesic drug classes and techniques, is now the recommended approach for postoperative pain management. Local infiltration at the incision site is one of the very effective methods for controlling postoperative pain. Various adjuvants have been used to prolong analgesic duration and improve wound infiltration quality [11].

The present study demonstrated that the addition of dexmedetomidine to bupivacaine (Group D) provided the longest duration of analgesia compared to bupivacaine-fentanyl (Group F) and bupivacaine alone (Group B). The time to first onset of pain and the time to first rescue analgesic were significantly longer in Group D ($p < 0.001$). These findings are similar to previous studies which demonstrate the peripheral analgesic effects of dexmedetomidine and fentanyl [5]. Similar results were reported by Neha Kadayan et al., which showed that the addition of dexmedetomidine significantly extended postoperative analgesia and reduced rescue analgesic requirements [5].

Hemodynamic parameters showed significant differences among the three groups. Group D exhibited significant lower heart rates and blood pressure, suggesting a potential bradycardic and hypotensive effect. Despite these changes, oxygen saturation levels remained stable across all groups. There was no significant impact on respiratory function. These findings are consistent with studies that have evaluated the effects of dexmedetomidine and fentanyl on postoperative analgesia and hemodynamics [12,13].

Conclusion

The current study demonstrates that adding dexmedetomidine to bupivacaine for local wound infiltration following abdominal hysterectomy significantly prolongs postoperative analgesia compared to bupivacaine-fentanyl and bupivacaine alone. Patients in the study group experienced a delayed onset of post-surgical pain, reduced need for rescue analgesics, and better pain control over a 24-hour period. Fentanyl also provided superior analgesia compared to bupivacaine alone. The effect was less pronounced than dexmedetomidine. The use of dexmedetomidine as an adjuvant in local infiltration not only enhances pain relief but also minimizes opioid consumption. Minimal opioid consumption results in reduction of opioid-related side effects. Additionally, the hemodynamic stability observed with dexmedetomidine suggests that it can be safely used without significant adverse effects.

Statements and Declarations

Conflicts of interest

The authors declare that they do not have conflict of interest.

Funding

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