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Research Article

Comparison of Dexmedetomidine versus Fentanyl as Adjuvants to General Anesthesia in Laparoscopic Procedures

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ABSTRACT
Background: Laparoscopic surgeries are associated with significant hemodynamic changes due to laryngoscopy, tracheal intubation, and pneumoperitoneum. Various anesthetic adjuvants are used to attenuate these stress responses and improve perioperative outcomes. Dexmedetomidine and fentanyl are commonly employed agents with distinct pharmacological profiles.
Aim: To compare dexmedetomidine and fentanyl as adjuvants to general anesthesia in patients undergoing laparoscopic procedures.
Methods: This prospective, randomized, comparative study was conducted in the Department of Anaesthesiology, St. Joseph's Hospital, Choondal, Thrissur, Kerala, from 2016 to 2018. A total of 60 patients undergoing elective laparoscopic surgeries under general anesthesia were enrolled and divided into two groups of 30 patients each. Group D received dexmedetomidine, while Group F received fentanyl. Hemodynamic parameters, anesthetic requirements, postoperative pain scores, recovery characteristics, and adverse effects were recorded and analyzed.
Results: The demographic characteristics were comparable between the groups ($p > 0.05$). Dexmedetomidine provided significantly better control of heart rate and mean arterial pressure during intubation and pneumoperitoneum compared with fentanyl ($p < 0.001$). The requirements for propofol, isoflurane, and supplemental analgesics were significantly lower in the dexmedetomidine group ($p < 0.05$). Postoperative pain scores at 1, 4, 8, and 24 hours were significantly reduced in patients receiving dexmedetomidine ($p < 0.05$). Time to first analgesic request was prolonged, while extubation time and PACU stay were shorter in the dexmedetomidine group. Postoperative nausea and vomiting were significantly less frequent with dexmedetomidine.
Conclusion: Dexmedetomidine is a safe and effective adjuvant to general anesthesia, providing superior hemodynamic stability, reduced anesthetic requirements, better postoperative analgesia, and improved recovery compared with fentanyl in laparoscopic procedures.

Keywords: Dexmedetomidine, Fentanyl, General Anesthesia, Laparoscopic Surgery, Hemodynamic Stability, Postoperative Analgesia, Recovery Profile, Pneumoperitoneum.

INTRODUCTION

Laparoscopic surgery has become the preferred approach for a wide range of abdominal and pelvic procedures owing to its minimally invasive nature, reduced postoperative pain, shorter hospital stay, faster recovery, and improved cosmetic outcomes compared to conventional open surgery [1]. Despite these advantages, laparoscopic procedures present unique anesthetic challenges resulting from the creation of pneumoperitoneum and changes in patient positioning. Carbon dioxide insufflation increases intra-abdominal pressure, leading to significant cardiovascular and respiratory alterations such as increased systemic vascular resistance, fluctuations in heart rate and blood pressure, reduced venous return, and impaired pulmonary compliance [2]. Therefore, maintenance of adequate intraoperative hemodynamic stability remains a critical objective during anesthesia for laparoscopic surgeries.

General anesthesia is the standard anesthetic technique employed for most laparoscopic procedures. However, laryngoscopy, tracheal intubation, surgical stimulation, and pneumoperitoneum can trigger marked sympathetic responses, resulting in tachycardia and hypertension [3]. These stress responses may increase perioperative morbidity, particularly in patients with underlying cardiovascular disease. Consequently, various anesthetic adjuvants have been investigated to

attenuate these responses and improve perioperative outcomes.

Fentanyl, a potent synthetic opioid agonist, has been widely used as an adjunct to general anesthesia due to its excellent analgesic properties, rapid onset of action, and ability to blunt sympathetic responses associated with surgical stimulation [4]. It effectively reduces intraoperative anesthetic requirements and provides satisfactory analgesia. However, its use may be associated with adverse effects such as respiratory depression, postoperative nausea and vomiting, delayed recovery, and opioid-induced hyperalgesia, especially when administered in higher doses [5]. These concerns have prompted interest in alternative agents that can provide comparable analgesia with fewer side effects.

Dexmedetomidine is a highly selective α2-adrenergic receptor agonist that has gained considerable popularity in modern anesthetic practice. It produces sedation, analgesia, anxiolysis, and sympatholysis without causing significant respiratory depression [6]. By decreasing central sympathetic outflow and inhibiting norepinephrine release, dexmedetomidine effectively attenuates hemodynamic responses to intubation, surgical stress, and pneumoperitoneum [7]. Additionally, it has been shown to reduce anesthetic and opioid requirements while facilitating smoother recovery and improving postoperative pain control [8].

Several studies have compared dexmedetomidine and fentanyl as adjuvants to general anesthesia in laparoscopic surgeries. Evidence suggests that dexmedetomidine may provide superior hemodynamic stability, lower perioperative analgesic requirements, and enhanced postoperative comfort compared with fentanyl [9]. Nevertheless, concerns regarding bradycardia and hypotension associated with dexmedetomidine continue to warrant careful evaluation [10]. Given the increasing emphasis on opioid-sparing anesthesia and enhanced recovery protocols, determining the relative benefits and limitations of these agents is of significant clinical importance.

The present study aims to compare dexmedetomidine and fentanyl as adjuvants to general anesthesia in patients undergoing laparoscopic procedures. The objectives are to evaluate intraoperative hemodynamic stability, anesthetic and analgesic requirements, postoperative pain relief, recovery characteristics, and the incidence of adverse effects associated with both agents.

MATERIALS AND METHODS

Study Design: Prospective, randomized, comparative clinical study.

Study Population: Adult patients scheduled to undergo elective laparoscopic surgical procedures under general anesthesia.

Sample Size: 60–70 patients (approximately 30–35 patients in each study group).

Study Duration: 2016–2018.

Study Place: Department of Anaesthesiology, St. Joseph's Hospital, Choondal, Thrissur, and Kerala.

Inclusion Criteria:

- Patients aged 18–65 years.
- Patients of either sex.
- American Society of Anesthesiologists (ASA) physical status I and II.
- Patients scheduled for elective laparoscopic procedures under general anesthesia.
- Patients willing to participate and provide written informed consent.

Exclusion Criteria:

- Patients with known hypersensitivity to dexmedetomidine, fentanyl, or related drugs.
- Patients with significant cardiovascular disease (e.g., severe hypertension, arrhythmias, ischemic heart disease, heart block).
- Patients with severe hepatic or renal dysfunction.
- Patients with uncontrolled diabetes mellitus.
- Patients with chronic opioid use or substance abuse.
- Pregnant or lactating women.
- Patients with psychiatric or neurological disorders affecting assessment.
- Patients classified as ASA physical status III or above.
- Patients requiring conversion from laparoscopic to open surgery

Statistical Analysis

Data collected during the study were entered into Microsoft Excel and analyzed using the Statistical Package for Social Sciences (SPSS) software version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. The normality of

data distribution was assessed using the Shapiro–Wilk test. Comparison of continuous variables between the Dexmedetomidine and Fentanyl groups was performed using the independent Student's t-test for normally distributed data. For non-normally distributed variables, the Mann–Whitney U test was applied. Categorical variables such as gender distribution, ASA status, and incidence of adverse effects were compared using the Chi-square test or Fisher's exact test wherever appropriate. Repeated measurements of hemodynamic parameters at different time intervals were analyzed using repeated-measures analysis of variance (ANOVA), followed by post-hoc testing when required. A p-value of less than 0.05 was considered statistically significant, while a p-value less than 0.001 was considered highly significant. The results were presented in the form of tables, charts, and graphs for appropriate interpretation and comparison between the study groups.

RESULT

Table 1. Demographic Characteristics

Variable	Dexmedetomidine (N=30)	Fentanyl (N=30)	P-Value
Age (Years)	42.6 ± 10.4	43.8 ± 9.7	0.651
Male/Female	18-Dec	17/13	0.793
Weight (Kg)	63.5 ± 8.2	64.7 ± 7.9	0.568
BMI (Kg/M²)	24.1 ± 2.8	24.6 ± 3.1	0.514
ASA I/II	20-Oct	19-Nov	0.781

Table 2. Intraoperative Hemodynamic Parameters

Parameter	Dexmedetomidine	Fentanyl	P-Value
Baseline HR (Bpm)	82.4 ± 8.6	83.1 ± 7.9	0.742
HR After Intubation (Bpm)	88.6 ± 9.2	98.8 ± 10.4	<0.001
Mean Arterial Pressure After Intubation (Mmhg)	89.4 ± 7.3	97.6 ± 8.5	<0.001
HR During Pneumoperitoneum (Bpm)	84.8 ± 8.7	94.5 ± 9.8	<0.001
MAP During Pneumoperitoneum (Mmhg)	87.6 ± 6.9	95.2 ± 8.1	<0.001

Table 3. Intraoperative Anesthetic and Analgesic Requirements

Variable	Dexmedetomidine	Fentanyl	P-Value
Propofol Requirement (Mg)	118.5 ± 18.4	136.8 ± 22.1	0.001
Isoflurane Concentration (%)	0.78 ± 0.12	1.02 ± 0.16	<0.001
Additional Analgesic Requirement (N)	4 (13.3%)	12 (40.0%)	0.019

Table 4. Postoperative Pain Scores (VAS)

Time After Surgery	Dexmedetomidine	Fentanyl	P-Value
1 Hour	2.1 ± 0.8	3.5 ± 1.0	<0.001
4 Hours	2.8 ± 0.9	4.2 ± 1.1	<0.001
8 Hours	3.2 ± 0.8	4.5 ± 1.2	<0.001
24 Hours	2.4 ± 0.7	3.1 ± 0.9	0.002

Table 5. Recovery Profile

Variable	Dexmedetomidine	Fentanyl	P-Value
Extubation Time (Min)	8.6 ± 2.1	10.4 ± 2.8	0.006
Time To First Analgesic Request (Min)	221.4 ± 38.7	145.6 ± 31.2	<0.001
PACU Stay (Min)	46.5 ± 8.9	53.8 ± 10.4	0.004

Table 6. Adverse Effects

Adverse Effect	Dexmedetomidine (N=30)	Fentanyl (N=30)	P-Value
Bradycardia	4 (13.3%)	1 (3.3%)	0.161
Hypotension	3 (10.0%)	2 (6.7%)	0.64
Nausea/Vomiting	2 (6.7%)	8 (26.7%)	0.038
Respiratory Depression	0 (0%)	3 (10.0%)	0.076
Shivering	1 (3.3%)	5 (16.7%)	0.085

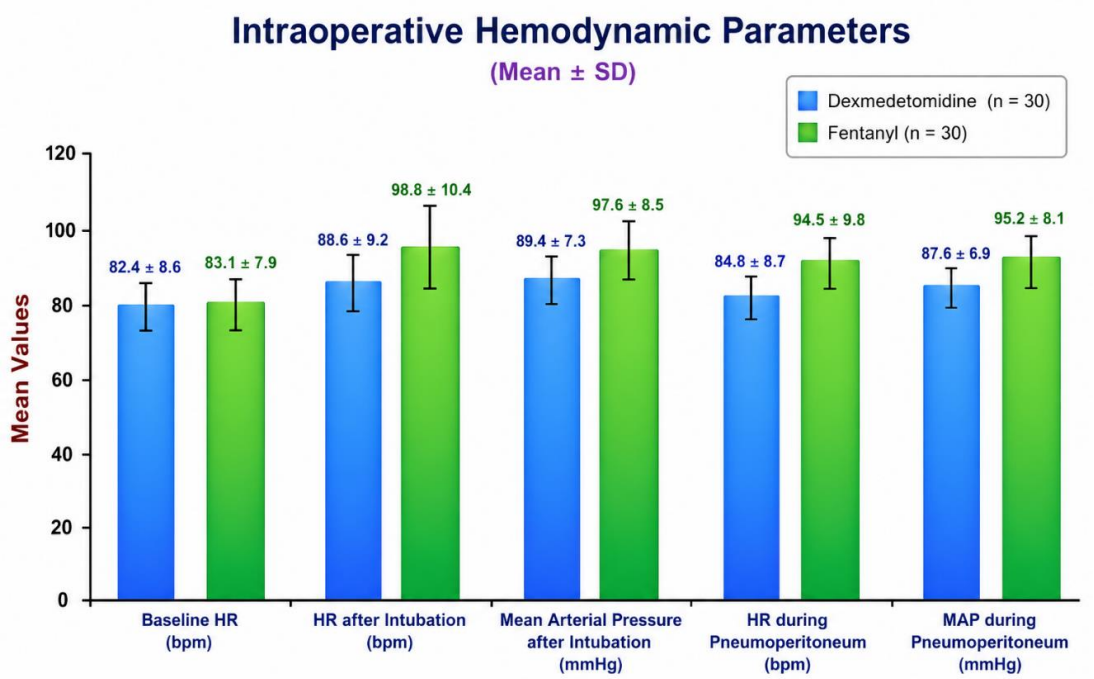

Figure: 1. Comparison of Intraoperative Hemodynamic Parameters between Dexmedetomidine and Fentanyl Groups

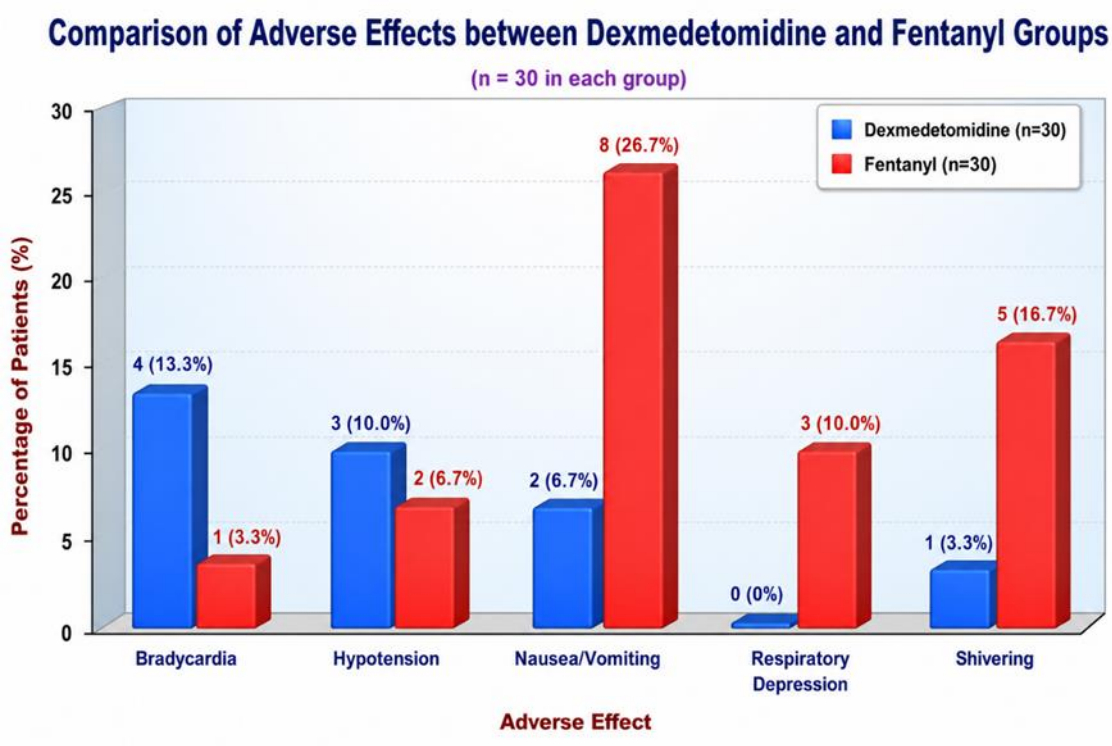

Figure: 2. Comparison of Adverse Effects between Dexmedetomidine and FentanylGroups

The demographic characteristics of the study participants were comparable between the two groups. The mean age of patients in the Dexmedetomidine group was 42.6 ± 10.4 years, while that in the Fentanyl group was 43.8 ± 9.7 years (p = 0.651). The gender distribution was also similar, with 18 males and 12 females in the Dexmedetomidine group compared to 17 males and 13 females in the Fentanyl group (p = 0.793). The mean body

weight was 63.5 ± 8.2 kg in the Dexmedetomidine group and 64.7 ± 7.9 kg in the Fentanyl group (p = 0.568). Similarly, the mean BMI was 24.1 ± 2.8 kg/m² and 24.6 ± 3.1 kg/m², respectively (p = 0.514). The distribution of ASA physical status I and II patients was also comparable between the groups (p = 0.781). These findings indicate that both groups were well matched at baseline, allowing meaningful comparison of perioperative outcomes.

The Dexmedetomidine group demonstrated significantly better intraoperative hemodynamic stability compared to the Fentanyl group. Baseline heart rate was similar in both groups (82.4 ± 8.6 bpm vs. 83.1 ± 7.9 bpm; p = 0.742). However, following tracheal intubation, the mean heart rate increased to 88.6 ± 9.2 bpm in the Dexmedetomidine group compared to 98.8 ± 10.4 bpm in the Fentanyl group, and this difference was highly significant (p < 0.001). Likewise, the mean arterial pressure after intubation was significantly lower in the Dexmedetomidine group (89.4 ± 7.3 mmHg) than in the Fentanyl group (97.6 ± 8.5 mmHg, p < 0.001). During pneumoperitoneum, the mean heart rate remained lower in the Dexmedetomidine group (84.8 ± 8.7 bpm) compared with the Fentanyl group (94.5 ± 9.8 bpm, p < 0.001). Mean arterial pressure during pneumoperitoneum was also significantly lower in the Dexmedetomidine group (87.6 ± 6.9 mmHg) than in the Fentanyl group (95.2 ± 8.1 mmHg, p < 0.001). These findings suggest superior attenuation of sympathetic responses with dexmedetomidine.

Patients receiving dexmedetomidine required significantly lower doses of anesthetic and supplemental analgesic agents than those receiving fentanyl. The mean propofol requirement in the Dexmedetomidine group was 118.5 ± 18.4 mg, compared to 136.8 ± 22.1 mg in the Fentanyl group (p = 0.001). Similarly, the mean isoflurane concentration required to maintain adequate anesthesia was significantly lower in the Dexmedetomidine group (0.78 ± 0.12%) than in the Fentanyl group (1.02 ± 0.16%, p < 0.001). Additional intraoperative analgesic supplementation was required in only 4 patients (13.3%) in the Dexmedetomidine group, whereas 12 patients (40.0%) in the Fentanyl group required supplemental analgesia (p = 0.019). These observations indicate that dexmedetomidine possesses significant anesthetic- and opioid-sparing effects.

Postoperative pain assessment using the Visual Analogue Scale (VAS) demonstrated significantly better analgesia in the Dexmedetomidine group. At 1 hour postoperatively, the mean VAS score was 2.1 ± 0.8 in the Dexmedetomidine group compared to 3.5 ± 1.0 in the Fentanyl group (p < 0.001). At 4 hours, the corresponding values were 2.8 ± 0.9 and 4.2 ± 1.1, respectively (p < 0.001). Similar differences were observed at 8 hours (3.2 ± 0.8 vs. 4.5 ± 1.2; p < 0.001) and 24 hours (2.4 ± 0.7 vs. 3.1 ± 0.9; p = 0.002). The consistently lower pain scores in the Dexmedetomidine group indicate prolonged and more effective postoperative analgesia compared to fentanyl.

Recovery characteristics were significantly improved in patients receiving dexmedetomidine. The mean extubation time was 8.6 ± 2.1 minutes in the Dexmedetomidine group compared with 10.4 ± 2.8 minutes in the Fentanyl group (p = 0.006). Furthermore, the mean time to first postoperative analgesic request was significantly prolonged in the Dexmedetomidine group (221.4 ± 38.7 minutes) compared to the Fentanyl group (145.6 ± 31.2 minutes, p < 0.001). The duration of stay in the post-anesthesia care unit (PACU) was also shorter in the Dexmedetomidine group (46.5 ± 8.9 minutes) than in the Fentanyl group (53.8 ± 10.4 minutes, p = 0.004). These findings indicate faster recovery and superior postoperative comfort with dexmedetomidine.

The incidence of adverse effects was generally low in both groups. Bradycardia was observed in 4 patients (13.3%) in the Dexmedetomidine group and 1 patient (3.3%) in the Fentanyl group; however, this difference was not statistically significant (p = 0.161). Hypotension occurred in 3 patients (10.0%) receiving dexmedetomidine and 2 patients (6.7%) receiving fentanyl (p = 0.640). Postoperative nausea and vomiting were significantly less frequent in the Dexmedetomidine group, affecting only 2 patients (6.7%), compared with 8 patients (26.7%) in the Fentanyl group (p = 0.038). Respiratory depression was not observed in the Dexmedetomidine group but occurred in 3 patients (10.0%) in the Fentanyl group (p = 0.076). Similarly, postoperative shivering occurred in 1 patient (3.3%) in the Dexmedetomidine group and 5 patients (16.7%) in the Fentanyl group (p = 0.085). Overall, dexmedetomidine was associated with a favorable safety profile, with significantly lower postoperative nausea and vomiting and no episodes of respiratory depression.

DISCUSSION

In the present study, both groups were comparable with respect to age, gender distribution, body weight, BMI, and ASA physical status, indicating successful randomization and minimizing potential confounding factors. The mean age was 42.6 ± 10.4 years in the Dexmedetomidine group and 43.8 ± 9.7 years in the Fentanyl group, with no statistically significant difference ($p = 0.651$). Similar demographic comparability was reported by Bajwa et al. [11], who compared dexmedetomidine and fentanyl during laparoscopic procedures and found no significant differences in age, sex distribution, or body weight between study groups. Likewise, Gupta et al. [12] observed comparable baseline characteristics among patients receiving dexmedetomidine and fentanyl, ensuring that differences in perioperative outcomes could be attributed to the study drugs rather than patient-related variables. The similarity in demographic parameters in the present study strengthens the validity of subsequent comparisons and aligns well with previous literature evaluating these anesthetic adjuvants.

A major finding of the present study was the superior hemodynamic stability achieved with dexmedetomidine. Following intubation and during pneumoperitoneum, heart rate and mean arterial pressure remained significantly lower in the Dexmedetomidine group compared with the Fentanyl group ($p < 0.001$). These findings are consistent with those reported by Tanskanen et al. [13], who demonstrated that dexmedetomidine effectively attenuated sympathetic responses to surgical stimulation and airway manipulation. Similarly, Bhattacharjee et al. [14] reported significantly lower heart rate and blood pressure values during laparoscopic cholecystectomy in patients receiving dexmedetomidine compared with fentanyl. The sympatholytic action of dexmedetomidine, mediated through central α2-adrenoceptor activation and reduced norepinephrine release, likely accounts for the observed hemodynamic stability. The findings of the present study therefore reinforce existing evidence supporting dexmedetomidine as an effective agent for blunting stress responses during laparoscopic surgery.

The present study demonstrated significantly reduced propofol and isoflurane requirements in patients receiving dexmedetomidine. Additional analgesic supplementation was also required less frequently in the Dexmedetomidine group (13.3%) than in the Fentanyl group (40.0%). Similar observations were made by Aho et al. [15], who found that dexmedetomidine significantly decreased anesthetic requirements due to its sedative and analgesic properties. In another study, Gurbet et al. [16] reported a substantial reduction in inhalational anesthetic consumption and perioperative opioid requirements among patients receiving dexmedetomidine infusions. The anesthetic-sparing effect observed in the present study can be attributed to the ability of dexmedetomidine to provide analgesia and sedation through activation of α2 receptors in the locus coeruleus and spinal cord. Reduced anesthetic consumption may contribute to improved recovery profiles and fewer anesthetic-related adverse effects.

Postoperative pain scores were significantly lower in the Dexmedetomidine group at all measured time points. These findings correlate with the results of Arain et al. [17], who observed superior postoperative analgesia and lower pain scores among patients receiving dexmedetomidine compared to opioid-based regimens. Similarly, Unlugenc et al. [18] reported that dexmedetomidine prolonged postoperative analgesia and reduced pain intensity following laparoscopic procedures. The prolonged analgesic action of dexmedetomidine may be explained by inhibition of nociceptive neurotransmitter release and modulation of pain pathways within the central nervous system. The lower VAS scores observed in the present study suggest that dexmedetomidine provides more effective postoperative pain control than fentanyl while simultaneously reducing opioid exposure.

Patients in the Dexmedetomidine group exhibited significantly faster extubation, prolonged time to first analgesic request, and shorter PACU stay. These findings are in agreement with those reported by Patel et al. [19], who observed smoother emergence and earlier recovery in patients receiving dexmedetomidine during laparoscopic surgery. Similar results were described by Hofer et al. [20], who found that dexmedetomidine improved recovery quality and reduced postoperative discomfort despite providing effective intraoperative sedation and analgesia. The prolonged postoperative analgesia observed in the present study likely contributed to delayed

analgesic demand and enhanced patient comfort. Faster recovery and reduced PACU stay are particularly beneficial in modern perioperative practice, where early mobilization and enhanced recovery protocols are increasingly emphasized.

The incidence of adverse effects in the present study was low in both groups. Although bradycardia occurred more frequently in the Dexmedetomidine group, the difference was not statistically significant. Conversely, postoperative nausea and vomiting were significantly less common in the Dexmedetomidine group than in the Fentanyl group. Similar findings have been reported by Bhana et al. [21], who noted that dexmedetomidine was associated with a lower incidence of opioid-related side effects, particularly nausea and vomiting. Hall et al. [22] also reported minimal respiratory depression and favorable tolerability with dexmedetomidine administration. The absence of respiratory depression in the Dexmedetomidine group in the present study further highlights an important advantage of dexmedetomidine over opioid-based analgesia. Overall, the safety profile observed supports the growing preference for dexmedetomidine as part of opioid-sparing anesthetic strategies

CONCLUSION

The present study demonstrated that dexmedetomidine is a superior adjuvant to general anesthesia compared to fentanyl in patients undergoing laparoscopic procedures. Dexmedetomidine provided significantly better attenuation of hemodynamic responses during laryngoscopy, tracheal intubation, and pneumoperitoneum, resulting in improved intraoperative cardiovascular stability. It was also associated with reduced anesthetic and analgesic requirements, reflecting its anesthetic- and opioid-sparing effects. Postoperative pain scores were significantly lower in the dexmedetomidine group, with a longer duration of analgesia and delayed requirement for rescue analgesics. Furthermore, patients receiving dexmedetomidine experienced faster recovery, earlier extubation, and shorter PACU stay. Although a slightly higher incidence of bradycardia and hypotension was observed, these events were clinically manageable and did not affect overall patient outcomes. In contrast, fentanyl was associated with a higher incidence of postoperative nausea and vomiting. Therefore, dexmedetomidine appears to be a safe and effective alternative to fentanyl as an adjuvant to general anesthesia in laparoscopic surgeries

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