

COMPARATIVE EVALUATION OF DEXMEDETOMIDINE VERSUS FENTANYL FOR ATTENUATION OF HEMODYNAMIC RESPONSE DURING LAPAROSCOPIC SURGERY

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ABSTRACT

Background: Laparoscopic surgery is associated with significant haemodynamic alterations resulting from laryngoscopy, endotracheal intubation, carbon dioxide pneumoperitoneum, surgical stimulation, and extubation. These changes may lead to undesirable increases in heart rate and arterial blood pressure. Dexmedetomidine and fentanyl are commonly used agents for attenuation of sympathetic responses during general anaesthesia, but their relative efficacy during laparoscopic procedures remains clinically important. The aim is to compare dexmedetomidine and fentanyl for attenuation of haemodynamic responses during laparoscopic surgery under general anaesthesia. **Materials and Methods:** This prospective, randomized, comparative study included 84 patients aged 18–60 years with ASA physical status I or II undergoing elective laparoscopic surgery. Patients were randomly allocated into two equal groups of 42 each. Group D received intravenous dexmedetomidine 1 µg/kg over 10 minutes before induction, while Group F received intravenous fentanyl 2 µg/kg. Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were recorded at baseline and at predefined intervals following drug administration, intubation, pneumoperitoneum, release of pneumoperitoneum, and extubation. Adverse events and rescue medication requirements were also documented. Data were analyzed using SPSS version 27.0, with $p < 0.05$ considered statistically significant. **Results:** Baseline characteristics were comparable between the groups. Immediately after intubation, HR was significantly lower in Group D than Group F (76.20 ± 8.00 vs 88.70 ± 9.20 beats/min; $p < 0.001$). Corresponding SBP values were 124.80 ± 10.10 vs 141.60 ± 11.80 mmHg, while MAP values were 91.70 ± 7.90 vs 104.80 ± 9.10 mmHg ($p < 0.001$). Significant haemodynamic differences persisted during pneumoperitoneum and after extubation. Rescue antihypertensive medication was required in 4.76% of Group D compared with 21.43% of Group F ($p = 0.048$), while tachycardia occurred in 2.38% versus 19.05%, respectively ($p = 0.029$). **Conclusion:** Dexmedetomidine provided superior attenuation of haemodynamic responses during laparoscopic surgery compared with fentanyl and was associated with lower rescue antihypertensive requirement and less tachycardia. It may therefore be a useful agent for maintaining perioperative haemodynamic stability.

INTRODUCTION

Laparoscopic surgery has become an essential component of modern surgical practice because it enables a wide range of abdominal procedures to be performed through small incisions with reduced tissue trauma and favorable postoperative recovery. Despite these advantages, laparoscopic procedures present important challenges to the anaesthesiologist. General anaesthesia, airway manipulation, patient positioning, and carbon dioxide insufflation can influence cardiovascular and respiratory physiology throughout surgery. Creation of pneumoperitoneum increases intra-abdominal pressure and may alter venous return, systemic vascular resistance, cardiac output, arterial pressure, and tissue perfusion. Carbon dioxide absorption may additionally contribute to hypercarbia and sympathetic activation. Therefore, preservation of stable perioperative haemodynamics remains an important component of safe anaesthetic management during laparoscopic procedures.^[1] Laryngoscopy and endotracheal intubation represent another important period of cardiovascular stress. Mechanical stimulation of the pharynx, larynx, and trachea activates sympathoadrenal pathways, which may produce sudden increases in heart rate and arterial blood pressure. During laparoscopic surgery, this initial response may be followed by additional haemodynamic alterations after establishment of pneumoperitoneum. Increased intra-abdominal pressure, neurohumoral activation, and carbon dioxide absorption can collectively influence cardiovascular function. Although such changes may be tolerated by healthy individuals, marked fluctuations may be undesirable in patients with limited cardiovascular reserve. Consequently, several pharmacological strategies have been investigated to attenuate sympathetic responses while maintaining adequate tissue perfusion and anaesthetic depth.^[2] Dexmedetomidine is a highly selective alpha-2 adrenergic receptor agonist that has acquired an important role as an adjunct to general anaesthesia. Its pharmacological actions include sympatholysis, sedation, anxiolysis, and analgesic-sparing effects. Central alpha-2 receptor activation decreases sympathetic outflow and reduces norepinephrine release, thereby limiting excessive increases in heart rate and arterial pressure during stressful perioperative events. An important characteristic of dexmedetomidine is its ability to provide sedation and sympatholysis with relatively limited respiratory depression. These properties make it particularly attractive when attenuation of cardiovascular responses is required without excessive suppression of spontaneous respiratory activity. However, its sympatholytic effects may also produce bradycardia and hypotension, making appropriate dose selection and continuous haemodynamic monitoring essential.^[3] Fentanyl is a potent synthetic opioid commonly incorporated into

balanced general anaesthesia because of its rapid onset, powerful analgesic effect, and ability to reduce sympathetic responses to painful stimulation. It has traditionally been used to attenuate the cardiovascular response associated with laryngoscopy, tracheal intubation, surgical incision, and other noxious stimuli. Nevertheless, greater attention is now being directed toward reducing unnecessary perioperative opioid exposure. Opioids can be associated with respiratory depression, sedation, nausea, vomiting, delayed gastrointestinal recovery, urinary retention, and other undesirable effects. Contemporary multimodal anaesthesia therefore aims to provide effective analgesia and suppression of surgical stress while limiting opioid-related adverse effects whenever clinically appropriate.^[4] Comparison of dexmedetomidine with fentanyl is clinically relevant because the two drugs attenuate sympathetic responses through different pharmacological pathways. Fentanyl primarily acts through μ -opioid receptors to provide analgesia and suppress nociceptive transmission, whereas dexmedetomidine acts predominantly through alpha-2 adrenergic receptors to reduce central sympathetic outflow while providing sedative and analgesic-sparing actions. The haemodynamic response to laryngoscopy and intubation provides an objective clinical model for comparing these drugs because changes in heart rate and arterial pressure can be monitored at predefined intervals. Recent evidence has therefore continued to evaluate their relative role in controlling peri-intubation cardiovascular responses during general anaesthesia.^[5] The clinical significance of this comparison extends beyond endotracheal intubation. Laparoscopic surgery produces repeated periods of physiological stimulation, including induction of anaesthesia, airway instrumentation, creation and maintenance of pneumoperitoneum, surgical manipulation, release of pneumoperitoneum, and tracheal extubation. Accordingly, an anaesthetic adjunct that provides sustained haemodynamic control throughout these events may be preferable to one whose effect is primarily confined to airway stimulation. Both dexmedetomidine and fentanyl continue to be evaluated as agents for attenuating perioperative cardiovascular responses, with particular interest in their influence on heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure.^[6]

MATERIALS AND METHODS

This prospective, randomized, comparative study was conducted in the Department of Anaesthesiology at a tertiary care hospital to compare the efficacy of intravenous dexmedetomidine and fentanyl in attenuating the hemodynamic response associated with laryngoscopy, endotracheal intubation, creation of pneumoperitoneum, and laparoscopic surgery. A

total of 84 patients scheduled for elective laparoscopic procedures under general anaesthesia were enrolled. Patients were allocated into two equal groups of 42 patients each, with Group D receiving dexmedetomidine and Group F receiving fentanyl. Adult patients of either sex, aged 18–60 years, belonging to the American Society of Anesthesiologists (ASA) physical status I or II and scheduled for elective laparoscopic surgery under general anaesthesia were considered eligible. Only patients who provided written informed consent and were suitable for the standardized anaesthetic technique were included in the study.

Inclusion Criteria

Patients aged 18–60 years, of either gender, with ASA physical status I or II and undergoing elective laparoscopic surgery under general anaesthesia with endotracheal intubation were included. Patients were required to have stable preoperative hemodynamic parameters and no contraindication to either dexmedetomidine or fentanyl.

Exclusion Criteria

Patients with ASA physical status III or above, significant cardiovascular disease, uncontrolled hypertension, cardiac arrhythmias, severe respiratory disease, hepatic or renal dysfunction, neurological or psychiatric disorders, anticipated difficult airway, pregnancy, morbid obesity, known allergy or hypersensitivity to the study drugs, chronic opioid or sedative use, and patients receiving drugs significantly affecting heart rate or blood pressure were excluded. Patients requiring conversion from laparoscopic to open surgery or those developing major intraoperative complications were also excluded from the final comparative assessment.

Methodology

The 84 eligible patients were randomly allocated into two groups using a computer-generated randomization sequence. Group D (n=42) received intravenous dexmedetomidine 1 µg/kg diluted in normal saline and administered slowly over 10 minutes before induction, while Group F (n=42) received intravenous fentanyl 2 µg/kg, similarly diluted and administered before induction. The study medications were prepared in comparable volumes to maintain uniformity in drug administration.

Preoperative Assessment and Monitoring

All patients underwent detailed pre-anaesthetic evaluation, including medical history, physical examination, airway assessment, and routine laboratory investigations. On arrival in the operating room, standard monitoring was instituted, including continuous electrocardiography, non-invasive blood pressure, heart rate, peripheral oxygen saturation (SpO₂), end-tidal carbon dioxide (EtCO₂), and temperature monitoring. Baseline heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and SpO₂ were recorded before administration of the study drug.

Anaesthetic Technique

After preoxygenation with 100% oxygen for 3 minutes, general anaesthesia was induced using intravenous propofol 2–2.5 mg/kg. Neuromuscular blockade was achieved with an appropriate dose of a non-depolarizing muscle relaxant, followed by direct laryngoscopy and endotracheal intubation. Anaesthesia was maintained using oxygen, nitrous oxide or air, inhalational anaesthetic agent, and intermittent neuromuscular blockade as required. Mechanical ventilation was adjusted to maintain EtCO₂ within 35–40 mmHg. During laparoscopy, intra-abdominal pressure was maintained at approximately 12–14 mmHg whenever clinically feasible. At the end of surgery, residual neuromuscular blockade was reversed, and extubation was performed after adequate recovery of consciousness and protective airway reflexes.

Hemodynamic Assessment

The primary parameters assessed were HR, SBP, DBP, and MAP. Measurements were recorded at baseline, after administration of the study drug, immediately before induction, immediately after endotracheal intubation, and at 1, 3, 5, and 10 minutes after intubation. Hemodynamic variables were further recorded immediately after creation of pneumoperitoneum and at 5, 10, 15, 30, and 45 minutes during pneumoperitoneum, as applicable according to the duration of surgery. Measurements were also documented after release of pneumoperitoneum and following extubation. The magnitude of change from baseline values was used to assess attenuation of the sympathetic hemodynamic response.

Secondary Outcome Parameters

Secondary outcomes included the requirement for additional analgesic or antihypertensive medication, intraoperative anaesthetic requirement, time to recovery, and occurrence of adverse effects. Bradycardia, hypotension, hypertension, tachycardia, respiratory depression, excessive sedation, nausea, vomiting, and postoperative shivering were specifically recorded. Bradycardia and hypotension requiring intervention were treated according to standard institutional protocols. Postoperative pain and sedation were assessed during the immediate recovery period using appropriate clinical scoring systems.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics for Windows, Version 27.0. Continuous variables such as age, weight, HR, SBP, DBP, and MAP were expressed as mean ± standard deviation. Categorical variables were presented as frequencies and percentages. Normality of continuous data was assessed using the Shapiro–Wilk test. Intergroup comparison of normally distributed continuous variables was performed using the independent-samples t-test, while the Mann–Whitney U test was used for non-normally distributed data. Changes in hemodynamic variables over different time points were analyzed

using repeated-measures ANOVA, with appropriate post-hoc analysis when required. Categorical variables were compared using the Chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant.

RESULTS

[Table 1]: Comparison of demographic and baseline characteristics between the two groups

A total of 84 patients were included in the study, with 42 patients each in Group D and Group F. The mean age of patients in Group D was 40.26 ± 10.14 years compared with 39.81 ± 9.86 years in Group F. The difference in mean age between the two groups was not statistically significant ($p=0.837$). Similarly, the mean body weight was 64.52 ± 8.47 kg in Group D and 65.38 ± 9.12 kg in Group F, with no significant difference between the groups ($p=0.655$). Regarding gender distribution, Group D consisted of 23 (54.76%) males and 19 (45.24%) females, whereas Group F consisted of 21 (50.00%) males and 21 (50.00%) females. The difference in gender distribution was statistically non-significant ($p=0.662$). In terms of ASA physical status, 25 (59.52%) patients in Group D and 24 (57.14%) patients in Group F belonged to ASA Grade I, while 17 (40.48%) and 18 (42.86%) patients, respectively, belonged to ASA Grade II. The distribution of ASA grades was comparable between the two groups ($p=0.825$). The mean duration of surgery was 82.60 ± 18.40 minutes in Group D and 84.10 ± 19.20 minutes in Group F, and this difference was also statistically non-significant ($p=0.716$). Thus, both groups were comparable with respect to demographic characteristics, ASA physical status, and duration of surgery.

[Table 2]: Comparison of heart rate at different time intervals between the two groups

At baseline, the mean heart rate was 78.10 ± 8.40 beats/min in Group D and 77.60 ± 8.10 beats/min in Group F, with no statistically significant difference ($p=0.782$). Following administration of the study drug, the mean heart rate decreased to 69.40 ± 7.60 beats/min in Group D compared with 75.80 ± 8.00 beats/min in Group F, and the difference was statistically significant ($p<0.001$). Immediately before induction, the corresponding mean heart rates were 68.80 ± 7.40 and 74.90 ± 7.80 beats/min, respectively ($p<0.001$). Immediately after endotracheal intubation, the mean heart rate increased in both groups but was 76.20 ± 8.00 beats/min in Group D compared with 88.70 ± 9.20 beats/min in Group F ($p<0.001$). At 1 minute after intubation, the values were 74.80 ± 7.70 and 86.90 ± 8.90 beats/min, respectively; at 3 minutes, 72.30 ± 7.10 and 82.40 ± 8.40 beats/min; at 5 minutes, 70.90 ± 6.90 and 79.60 ± 8.00 beats/min; and at 10 minutes, 70.10 ± 6.80 and 76.20 ± 7.70 beats/min. At all these post-intubation intervals, the heart rate was significantly lower in Group D than in Group F

($p<0.001$). A similar pattern was observed following creation of pneumoperitoneum. Immediately after pneumoperitoneum, the mean heart rate was 74.60 ± 7.30 beats/min in Group D compared with 84.90 ± 8.70 beats/min in Group F ($p<0.001$). At 5, 10, 15, 30, and 45 minutes during pneumoperitoneum, the respective mean heart rates in Group D were 73.80 ± 7.10 , 72.90 ± 7.00 , 72.10 ± 6.80 , 71.60 ± 6.90 , and 71.40 ± 6.70 beats/min, while those in Group F were 83.70 ± 8.40 , 81.60 ± 8.20 , 79.80 ± 7.90 , 78.20 ± 7.70 , and 77.10 ± 7.50 beats/min. All these differences were statistically significant ($p<0.001$). After release of pneumoperitoneum, the heart rate was 70.80 ± 6.80 beats/min in Group D and 75.60 ± 7.40 beats/min in Group F ($p=0.003$). Following extubation, the values increased to 76.90 ± 7.80 and 84.60 ± 8.50 beats/min, respectively, with a statistically significant difference ($p<0.001$).

[Table 3]: Comparison of systolic and diastolic blood pressure at selected time intervals

At baseline, mean systolic blood pressure was 122.40 ± 10.20 mmHg in Group D and 123.10 ± 10.60 mmHg in Group F ($p=0.759$), while mean diastolic blood pressure was 77.80 ± 7.60 mmHg and 78.10 ± 7.80 mmHg, respectively ($p=0.859$). Thus, both systolic and diastolic blood pressures were comparable between the groups at baseline. Following administration of the study drug, mean SBP decreased to 112.60 ± 9.40 mmHg in Group D compared with 119.40 ± 9.80 mmHg in Group F ($p=0.002$). Mean DBP at the same time was 70.90 ± 6.90 mmHg and 76.40 ± 7.20 mmHg, respectively ($p<0.001$). Immediately after intubation, mean SBP was 124.80 ± 10.10 mmHg in Group D compared with 141.60 ± 11.80 mmHg in Group F, while mean DBP was 75.20 ± 7.50 and 86.40 ± 8.10 mmHg, respectively. Both differences were statistically significant ($p<0.001$). At 5 minutes after intubation, mean SBP was 118.30 ± 9.60 mmHg in Group D and 132.10 ± 10.80 mmHg in Group F, whereas mean DBP was 71.80 ± 7.10 and 79.20 ± 7.60 mmHg, respectively. These differences also remained statistically significant ($p<0.001$). Immediately after creation of pneumoperitoneum, mean SBP was 125.10 ± 9.90 mmHg in Group D and 139.30 ± 11.10 mmHg in Group F, while mean DBP was 74.40 ± 7.20 and 83.50 ± 7.80 mmHg, respectively ($p<0.001$ for both comparisons). At 15 minutes of pneumoperitoneum, SBP remained lower in Group D at 120.60 ± 9.50 mmHg compared with 132.70 ± 10.40 mmHg in Group F, and DBP was 72.80 ± 7.00 versus 79.00 ± 7.50 mmHg, respectively ($p<0.001$ for both). Following release of pneumoperitoneum, mean SBP was 116.90 ± 9.30 mmHg in Group D and 123.70 ± 9.80 mmHg in Group F ($p=0.002$), whereas DBP was 71.90 ± 6.80 and 75.60 ± 7.20 mmHg, respectively ($p=0.018$). After extubation, mean SBP increased to 128.20 ± 10.40 mmHg in Group D and 138.60 ± 11.00 mmHg in Group F, while DBP was 76.80 ± 7.40 and 82.90 ± 7.90 mmHg, respectively. Both post-extubation differences were statistically significant ($p<0.001$).

[Table 4]: Comparison of mean arterial pressure at different time intervals

Baseline mean arterial pressure was comparable between the two groups, measuring 92.60 ± 7.80 mmHg in Group D and 93.10 ± 8.10 mmHg in Group F ($p=0.774$). After administration of the study drug, MAP decreased to 84.80 ± 7.10 mmHg in Group D compared with 90.70 ± 7.60 mmHg in Group F ($p<0.001$). Immediately before induction, the values were 83.90 ± 7.00 and 89.60 ± 7.40 mmHg, respectively, with a statistically significant difference ($p<0.001$). Immediately following intubation, MAP was 91.70 ± 7.90 mmHg in Group D compared with 104.80 ± 9.10 mmHg in Group F ($p<0.001$). At 1 minute after intubation, MAP was 90.40 ± 7.50 versus 102.60 ± 8.80 mmHg; at 3 minutes, 88.20 ± 7.30 versus 99.40 ± 8.40 mmHg; at 5 minutes, 86.90 ± 7.10 versus 96.80 ± 8.10 mmHg; and at 10 minutes, 86.10 ± 7.00 versus 93.70 ± 7.80 mmHg in Group D and Group F, respectively. At each of these intervals, the difference was statistically significant ($p<0.001$). Immediately following creation of pneumoperitoneum, MAP increased to 91.30 ± 7.50 mmHg in Group D and 102.10 ± 8.60 mmHg in Group F ($p<0.001$). At 5, 10, 15, 30, and 45 minutes of pneumoperitoneum, MAP in Group D was 90.50 ± 7.30 , 89.60 ± 7.20 , 88.70 ± 7.10 , 88.10 ± 7.00 , and 87.80 ± 6.90 mmHg, respectively. Corresponding values in Group F were 100.80 ± 8.40 , 98.70 ± 8.20 , 96.90 ± 8.00 , 95.30 ± 7.90 , and 94.10 ± 7.70 mmHg. The intergroup differences at all these time points were statistically significant ($p<0.001$). After release of pneumoperitoneum, MAP was 86.90 ± 7.00 mmHg in Group D and 91.90 ± 7.60 mmHg in Group F ($p=0.002$). Following extubation, MAP increased to 93.40 ± 7.80 mmHg in Group D and 101.50 ± 8.60

mmHg in Group F, with the difference remaining statistically significant ($p<0.001$).

[Table 5]: Comparison of secondary outcomes and adverse events between the two groups

Rescue antihypertensive medication was required in 2 (4.76%) patients in Group D compared with 9 (21.43%) patients in Group F. This difference was statistically significant ($p=0.048$). Additional intraoperative analgesic medication was required in 3 (7.14%) patients in Group D and 9 (21.43%) patients in Group F; however, this difference did not reach statistical significance ($p=0.116$). Bradycardia was observed in 6 (14.29%) patients in Group D compared with 2 (4.76%) patients in Group F, with no statistically significant difference ($p=0.265$). Hypotension occurred in 5 (11.90%) patients in Group D and 2 (4.76%) patients in Group F ($p=0.433$). Hypertension was observed in 1 (2.38%) patient in Group D compared with 7 (16.67%) patients in Group F; the difference approached but did not reach statistical significance ($p=0.057$). Tachycardia occurred in 1 (2.38%) patient in Group D compared with 8 (19.05%) patients in Group F, and this difference was statistically significant ($p=0.029$). Respiratory depression was not observed in any patient in Group D, while it occurred in 2 (4.76%) patients in Group F; the difference was statistically non-significant ($p=0.494$). Excessive sedation was recorded in 4 (9.52%) patients in Group D compared with 1 (2.38%) patient in Group F ($p=0.360$). Nausea and vomiting occurred in 2 (4.76%) patients in Group D and 5 (11.90%) patients in Group F ($p=0.433$). Postoperative shivering was reported in 1 (2.38%) patient in Group D compared with 4 (9.52%) patients in Group F, with no statistically significant difference between the groups ($p=0.360$).

Table1:Comparison of demographic and baseline characteristics between the two groups

Parameter	Group D (n=42)	Group F (n=42)	p-value
Age (years), Mean $\pm$ SD	40.26 $\pm$ 10.14	39.81 $\pm$ 9.86	0.837
Weight (kg), Mean $\pm$ SD	64.52 $\pm$ 8.47	65.38 $\pm$ 9.12	0.655
Male, n (%)	23 (54.76%)	21 (50.00%)	0.662
Female, n (%)	19 (45.24%)	21 (50.00%)	0.662
ASA Grade I, n (%)	25 (59.52%)	24 (57.14%)	0.825
ASA Grade II, n (%)	17 (40.48%)	18 (42.86%)	0.825
Duration of surgery (min), Mean $\pm$ SD	82.60 $\pm$ 18.40	84.10 $\pm$ 19.20	0.716

Table 2: Comparison of heart rate at different time intervals between the two groups

Time interval	Group D HR (beats/min), Mean $\pm$ SD	Group F HR (beats/min), Mean $\pm$ SD	p-value
Baseline	78.10 $\pm$ 8.40	77.60 $\pm$ 8.10	0.782
After study drug	69.40 $\pm$ 7.60	75.80 $\pm$ 8.00	<0.001
Pre-induction	68.80 $\pm$ 7.40	74.90 $\pm$ 7.80	<0.001
Immediately after intubation	76.20 $\pm$ 8.00	88.70 $\pm$ 9.20	<0.001
1 min after intubation	74.80 $\pm$ 7.70	86.90 $\pm$ 8.90	<0.001
3 min after intubation	72.30 $\pm$ 7.10	82.40 $\pm$ 8.40	<0.001
5 min after intubation	70.90 $\pm$ 6.90	79.60 $\pm$ 8.00	<0.001
10 min after intubation	70.10 $\pm$ 6.80	76.20 $\pm$ 7.70	<0.001
Immediately after pneumoperitoneum	74.60 $\pm$ 7.30	84.90 $\pm$ 8.70	<0.001
5 min pneumoperitoneum	73.80 $\pm$ 7.10	83.70 $\pm$ 8.40	<0.001
10 min pneumoperitoneum	72.90 $\pm$ 7.00	81.60 $\pm$ 8.20	<0.001
15 min pneumoperitoneum	72.10 $\pm$ 6.80	79.80 $\pm$ 7.90	<0.001
30 min pneumoperitoneum	71.60 $\pm$ 6.90	78.20 $\pm$ 7.70	<0.001
45 min pneumoperitoneum	71.40 $\pm$ 6.70	77.10 $\pm$ 7.50	<0.001

After release of pneumoperitoneum	70.80 ± 6.80	75.60 ± 7.40	0.003
After extubation	76.90 ± 7.80	84.60 ± 8.50	<0.001

Table 3: Comparison of systolic and diastolic blood pressure at selected time intervals

Time interval	Group D SBP (mmHg)	Group F SBP (mmHg)	p-value	Group D DBP (mmHg)	Group F DBP (mmHg)	p-value
Baseline	122.40 ± 10.20	123.10 ± 10.60	0.759	77.80 ± 7.60	78.10 ± 7.80	0.859
After study drug	112.60 ± 9.40	119.40 ± 9.80	0.002	70.90 ± 6.90	76.40 ± 7.20	<0.001
Immediately after intubation	124.80 ± 10.10	141.60 ± 11.80	<0.001	75.20 ± 7.50	86.40 ± 8.10	<0.001
5 min after intubation	118.30 ± 9.60	132.10 ± 10.80	<0.001	71.80 ± 7.10	79.20 ± 7.60	<0.001
Immediately after pneumoperitoneum	125.10 ± 9.90	139.30 ± 11.10	<0.001	74.40 ± 7.20	83.50 ± 7.80	<0.001
15 min pneumoperitoneum	120.60 ± 9.50	132.70 ± 10.40	<0.001	72.80 ± 7.00	79.00 ± 7.50	<0.001
After release of pneumoperitoneum	116.90 ± 9.30	123.70 ± 9.80	0.002	71.90 ± 6.80	75.60 ± 7.20	0.018
After extubation	128.20 ± 10.40	138.60 ± 11.00	<0.001	76.80 ± 7.40	82.90 ± 7.90	<0.001

Table 4: Comparison of mean arterial pressure at different time intervals

Time interval	Group D MAP (mmHg), Mean ± SD	Group F MAP (mmHg), Mean ± SD	p-value
Baseline	92.60 ± 7.80	93.10 ± 8.10	0.774
After study drug	84.80 ± 7.10	90.70 ± 7.60	<0.001
Pre-induction	83.90 ± 7.00	89.60 ± 7.40	<0.001
Immediately after intubation	91.70 ± 7.90	104.80 ± 9.10	<0.001
1 min after intubation	90.40 ± 7.50	102.60 ± 8.80	<0.001
3 min after intubation	88.20 ± 7.30	99.40 ± 8.40	<0.001
5 min after intubation	86.90 ± 7.10	96.80 ± 8.10	<0.001
10 min after intubation	86.10 ± 7.00	93.70 ± 7.80	<0.001
Immediately after pneumoperitoneum	91.30 ± 7.50	102.10 ± 8.60	<0.001
5 min pneumoperitoneum	90.50 ± 7.30	100.80 ± 8.40	<0.001
10 min pneumoperitoneum	89.60 ± 7.20	98.70 ± 8.20	<0.001
15 min pneumoperitoneum	88.70 ± 7.10	96.90 ± 8.00	<0.001
30 min pneumoperitoneum	88.10 ± 7.00	95.30 ± 7.90	<0.001
45 min pneumoperitoneum	87.80 ± 6.90	94.10 ± 7.70	<0.001
After release of pneumoperitoneum	86.90 ± 7.00	91.90 ± 7.60	0.002
After extubation	93.40 ± 7.80	101.50 ± 8.60	<0.001

Table 5: Comparison of secondary outcomes and adverse events between the two groups

Parameter	Group D (n=42), n (%)	Group F (n=42), n (%)	p-value
Rescue antihypertensive required	2 (4.76%)	9 (21.43%)	0.048
Additional intraoperative analgesic required	3 (7.14%)	9 (21.43%)	0.116
Bradycardia	6 (14.29%)	2 (4.76%)	0.265
Hypotension	5 (11.90%)	2 (4.76%)	0.433
Hypertension	1 (2.38%)	7 (16.67%)	0.057
Tachycardia	1 (2.38%)	8 (19.05%)	0.029
Respiratory depression	0 (0.00%)	2 (4.76%)	0.494
Excessive sedation	4 (9.52%)	1 (2.38%)	0.360
Nausea/vomiting	2 (4.76%)	5 (11.90%)	0.433
Postoperative shivering	1 (2.38%)	4 (9.52%)	0.360

DISCUSSION

The demographic characteristics of the two groups in the present study were well matched, reducing the likelihood that differences in haemodynamic outcomes were attributable to baseline characteristics. The mean age was 40.26 ± 10.14 years in Group D and 39.81 ± 9.86 years in Group F (p=0.837), while mean body weight was 64.52 ± 8.47 kg and 65.38 ± 9.12 kg, respectively (p=0.655). Gender distribution, ASA physical status, and duration of surgery were also comparable. Similar baseline comparability was reported by Vaswani et al. (2017), who studied 60 patients undergoing elective laparoscopic surgery. Their mean ages were 37.9 ± 13.17 years with dexmedetomidine and 34.7 ± 11.47 years with fentanyl, while mean weights were 55.93 ± 10.79 and 54.13 ± 10.96 kg,

respectively. ASA I/II distribution was 24/6 versus 25/5, and duration of surgery was 96.77 ± 31.04 versus 84.63 ± 17.79 minutes, with no significant baseline differences. This similarity between studies supports the appropriateness of subsequent intergroup haemodynamic comparisons.^[7] Heart rate was one of the most prominent parameters demonstrating a difference between the two study drugs. Although baseline HR was almost identical in the present study (78.10 ± 8.40 beats/min in Group D versus 77.60 ± 8.10 beats/min in Group F; p=0.782), immediately after intubation it was substantially lower with dexmedetomidine (76.20 ± 8.00 versus 88.70 ± 9.20 beats/min; p<0.001). The difference remained significant at 1, 3, 5, and 10 minutes after intubation. Neil et al. (2017) similarly demonstrated superior control of the chronotropic response with dexmedetomidine in 60 laparoscopic

surgical patients. In their study, heart rate after intubation decreased by approximately 2% from the preceding level with dexmedetomidine, whereas it increased by approximately 15% with fentanyl. They also reported that at intubation heart rate decreased by 3.51% in the dexmedetomidine group compared with an 11.11% increase in the fentanyl group. These observations closely parallel the markedly lower post-intubation HR demonstrated in the present study.^[8] The difference in heart rate persisted following creation of pneumoperitoneum. In the present study, immediately after pneumoperitoneum HR was 74.60 ± 7.30 beats/min in Group D compared with 84.90 ± 8.70 beats/min in Group F ($p < 0.001$), and at 15 minutes it remained lower at 72.10 ± 6.80 versus 79.80 ± 7.90 beats/min. Even at 45 minutes, values were 71.40 ± 6.70 and 77.10 ± 7.50 beats/min, respectively ($p < 0.001$). Gupta et al. (2013), in a randomized double-blind study of 60 patients undergoing laparoscopic cholecystectomy, compared dexmedetomidine $1 \mu\text{g/kg}$ with fentanyl $2 \mu\text{g/kg}$ and observed that perioperative variations in HR and arterial pressure remained within 15% of baseline in both groups; however, haemodynamic variables were consistently more stable in the dexmedetomidine group. Their observations during CO_2 pneumoperitoneum therefore support the present finding that dexmedetomidine offers more sustained suppression of the sympathetic response throughout laparoscopy rather than only during airway manipulation.^[9] The systolic and diastolic blood pressure findings further demonstrated attenuation of the pressor response with dexmedetomidine. Baseline SBP was comparable in the present study at 122.40 ± 10.20 mmHg in Group D and 123.10 ± 10.60 mmHg in Group F, but immediately following intubation the values were 124.80 ± 10.10 and 141.60 ± 11.80 mmHg, respectively ($p < 0.001$). Similarly, immediately after pneumoperitoneum SBP was 125.10 ± 9.90 versus 139.30 ± 11.10 mmHg ($p < 0.001$). DBP showed the same pattern, being 75.20 ± 7.50 versus 86.40 ± 8.10 mmHg immediately after intubation and 74.40 ± 7.20 versus 83.50 ± 7.80 mmHg after pneumoperitoneum. Kataria et al. (2016) reported closely comparable findings in 60 laparoscopic cholecystectomy patients. Their baseline SBP was 130.50 ± 5.13 mmHg with dexmedetomidine and 132.23 ± 7.09 mmHg with fentanyl; following intubation, SBP was 122.13 ± 9.34 versus 137.00 ± 5.68 mmHg, while during pneumoperitoneum values were approximately 119 ± 6 versus 133.42 ± 7.00 mmHg. They also noted that DBP remained below baseline with dexmedetomidine while tending to remain above baseline with fentanyl during surgery.^[10]

Mean arterial pressure followed a similar trend. Baseline MAP in the present study was comparable between Group D and Group F (92.60 ± 7.80 versus 93.10 ± 8.10 mmHg; $p = 0.774$), but immediately after intubation it was 91.70 ± 7.90 versus $104.80 \pm$

9.10 mmHg ($p < 0.001$). After pneumoperitoneum, MAP remained significantly lower with dexmedetomidine, including values of 88.70 ± 7.10 versus 96.90 ± 8.00 mmHg at 15 minutes and 87.80 ± 6.90 versus 94.10 ± 7.70 mmHg at 45 minutes. Bilgi et al. (2016) also demonstrated greater MAP stability with dexmedetomidine than fentanyl. In their randomized trial, baseline MAP was 102.45 ± 9.74 mmHg in the dexmedetomidine group and 101.82 ± 13.46 mmHg in the fentanyl group. Following laryngoscopy and intubation, MAP increased only to 108.07 ± 19.20 mmHg with dexmedetomidine ($p = 0.094$ compared with baseline), whereas it increased significantly to 113.86 ± 18.69 mmHg with fentanyl ($p = 0.004$). These findings support the lower and more stable MAP observed with dexmedetomidine in the present study.^[11]

A significant difference was also evident during emergence and extubation. In the present study, post-extubation HR was 76.90 ± 7.80 beats/min with dexmedetomidine compared with 84.60 ± 8.50 beats/min with fentanyl ($p < 0.001$); corresponding SBP values were 128.20 ± 10.40 and 138.60 ± 11.00 mmHg, and MAP values were 93.40 ± 7.80 and 101.50 ± 8.60 mmHg (both $p < 0.001$). Aksu et al. (2009) compared dexmedetomidine $0.5 \mu\text{g/kg}$ with fentanyl $1 \mu\text{g/kg}$ before tracheal extubation and similarly found that HR at 1, 5, and 10 minutes after extubation was significantly higher in the fentanyl group ($p = 0.003$ at each interval). Bradycardia occurred in 2 of 20 patients in each group, while emesis occurred in 2 patients receiving dexmedetomidine and 3 receiving fentanyl; one fentanyl-treated patient also developed vomiting and one developed shivering. Thus, their findings support the better control of the cardiovascular response to extubation observed with dexmedetomidine in the present study while also indicating the need to monitor for bradycardia.^[12]

The secondary outcomes of the present study were also consistent with an anaesthetic- and analgesic-sparing profile for dexmedetomidine. Rescue antihypertensive medication was required in only 2 (4.76%) patients in Group D compared with 9 (21.43%) in Group F ($p = 0.048$), while additional intraoperative analgesia was required in 3 (7.14%) versus 9 (21.43%) patients. Nausea/vomiting occurred in 2 (4.76%) versus 5 (11.90%), and postoperative shivering in 1 (2.38%) versus 4 (9.52%) patients. Vora et al. (2015), in 70 patients undergoing laparoscopic procedures, likewise demonstrated reduced supplementary drug requirements with dexmedetomidine. Only 3 of 35 patients receiving dexmedetomidine required additional intraoperative fentanyl compared with 11 of 35 controls ($p = 0.03$); postoperative tramadol was needed in 2 versus 10 patients ($p = 0.02$), and ondansetron for nausea/vomiting was required in only 1 versus 9 patients ($p = 0.01$). Bradycardia occurred in three dexmedetomidine-treated patients, whereas four control patients developed

postoperative shivering. Although their comparator was saline rather than fentanyl, these quantitative findings reinforce the opioid-sparing and antiemetic advantages suggested by the present results.^[13]

The superiority of dexmedetomidine observed in the present study should nevertheless be interpreted in the context of dose and administration technique. Tachycardia occurred in only 1 (2.38%) patient receiving dexmedetomidine compared with 8 (19.05%) receiving fentanyl ($p=0.029$), while hypertension occurred in 1 (2.38%) versus 7 (16.67%) patients. In contrast, Mahiswar et al. (2022) studied 100 patients receiving a single bolus of dexmedetomidine 0.5 µg/kg or fentanyl 2 µg/kg before laryngoscopy and found no statistically significant difference in HR or MAP between the groups at any measurement during the first 5 minutes after intubation; importantly, no patient required rescue medication for the observed haemodynamic changes.

The difference from the present findings may be related to their use of a lower dexmedetomidine dose, a single-bolus protocol, and evaluation limited principally to the intubation response rather than the sustained haemodynamic challenge produced by pneumoperitoneum. The present results therefore suggest that, under the dosing regimen used in this study, dexmedetomidine provides more sustained haemodynamic attenuation across intubation, pneumoperitoneum, intraoperative stimulation, and extubation, although careful surveillance for bradycardia and hypotension remains necessary.^[14]

CONCLUSION

Dexmedetomidine provided better attenuation of the haemodynamic responses associated with laryngoscopy, endotracheal intubation, pneumoperitoneum, and extubation compared with fentanyl. It maintained significantly lower heart rate, systolic and diastolic blood pressure, and mean arterial pressure at most perioperative time points. The requirement for rescue antihypertensive therapy and occurrence of tachycardia were also lower with dexmedetomidine. Overall, dexmedetomidine was more effective than fentanyl for maintaining perioperative haemodynamic stability during laparoscopic surgery, with an acceptable adverse-effect profile.

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