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Comparative Evaluation of Dexmedetomidine versus Fentanyl on Hemodynamic Response to Laryngoscopy, Pneumoperitoneum and Extubation in Laparoscopic Surgeries

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ABSTRACT

Background: Perioperative stress responses to laryngoscopy, pneumoperitoneum, and extubation can cause significant hemodynamic fluctuations, increasing the risk of cardiovascular complications. Dexmedetomidine, a selective α2-adrenergic agonist, has sympatholytic properties that may attenuate these responses. This study aimed to compare dexmedetomidine with fentanyl in controlling perioperative hemodynamic changes in laparoscopic surgeries.
Methods: In this prospective randomized study, 40 patients (ASA I–II) undergoing elective laparoscopic surgeries were allocated into two groups (n=20 each). Group D received dexmedetomidine (1 µg/kg loading dose followed by infusion), while Group F received fentanyl (1 µg/kg). Hemodynamic parameters including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were recorded at baseline, intubation, pneumoperitoneum, extubation, and postoperatively. Statistical analysis was performed using Student's t-test, with $p < 0.05$ considered significant.
Results: Baseline characteristics were comparable between groups. HR was significantly lower in Group D at baseline (78.0 ± 13.1 vs 88.2 ± 9.4 bpm, p = 0.007). Following intubation, HR was significantly attenuated in Group D (80.4 ± 12.3 vs 90.9 ± 15.4 bpm, p = 0.022). During pneumoperitoneum, HR (p = 0.012), SBP (p = 0.014), and DBP (p = 0.037) were significantly lower in Group D. At extubation, all parameters were significantly lower in Group D ($p < 0.001$). Postoperative hemodynamics remained significantly more stable in Group D ($p < 0.001$).
Conclusion: Dexmedetomidine provides superior attenuation of perioperative hemodynamic responses compared to fentanyl and ensures better overall hemodynamic stability in laparoscopic surgeries.

Keywords: *Dexmedetomidine; Fentanyl; Hemodynamic response; Laryngoscopy; Pneumoperitoneum; Extubation; Laparoscopic surgery; Heart rate; Blood pressure; Mean arterial pressure*

INTRODUCTION

Perioperative events such as endotracheal intubation, surgical stimulation, and extubation are associated with significant physiological stress, leading to increased catecholamine release and consequent elevations in heart rate and blood pressure (1). These responses are particularly concerning in patients with hypertension or coronary artery disease, where exaggerated hemodynamic fluctuations may increase the risk of myocardial ischemia and infarction (2,3). Therefore, attenuation of the sympathoadrenal stress response is a key objective in modern anesthetic practice.

Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, possesses sedative, analgesic, and sympatholytic properties with minimal respiratory depression (4). It has been shown to reduce anesthetic requirements and provide stable hemodynamics during surgery (5). Its ability to produce "cooperative sedation" and favorable safety profile has led to its increasing use in monitored anesthesia care and as an adjunct to general anesthesia (6,7). Additionally, dexmedetomidine offers anesthetic-sparing, cardioprotective, and neuroprotective effects, making it a valuable agent in perioperative management (8).

Dexmedetomidine is effective in attenuating hemodynamic responses to laryngoscopy, intubation, and extubation, with doses ranging from 0.25 to 1 µg/kg, and optimal efficacy observed at 1 µg/kg (9–12). Continuous intraoperative infusion has been associated with reduced hemodynamic variability and lower catecholamine levels (10). Moderate doses have also been shown to decrease emergence agitation and postoperative analgesic requirements without delaying recovery (13,14). However, its use may be associated with bradycardia and hypotension due to reduced sympathetic outflow. Transient hypertension may occur at higher doses due to peripheral α2 receptor stimulation, which typically resolves with central sympatholytic effects (15). Dexmedetomidine has also been shown to significantly reduce circulating catecholamine levels, contributing to its clinical benefits (16).

Objective of the study was to to evaluate and compare the effectiveness of dexmedetomidine and fentanyl in attenuating perioperative hemodynamic responses to laryngoscopy, pneumoperitoneum, and extubation in laparoscopic surgeries.

METHODOLOGY

Study Design and Setting

This prospective, randomized controlled study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants.

Study Population

A total of 40 patients of either gender, aged 18–60 years, belonging to American Society of Anesthesiologists (ASA) physical status I and II, scheduled for elective laparoscopic surgeries of short duration (2–3 hours) were included.

Exclusion Criteria

Patients with morbid obesity, pregnancy or lactation, cardiac conduction abnormalities (heart block), hypertension, those on β-blockers, renal disease, or those requiring multiple intubation attempts were excluded.

Randomization and Group Allocation

Patients were randomly allocated into two groups (n=20 each) using a simple randomization technique (slips in a box method):

- **Group D (Dexmedetomidine group)**
- **Group F (Fentanyl group)**

Intervention Protocol

All patients were premedicated with oral midazolam 7.5 mg one hour prior to surgery. Standard monitoring (ECG, heart rate, mean arterial pressure, SpO_2) was instituted.

- **Group D:** Received dexmedetomidine 1 µg/kg diluted in 20 mL normal saline over 10 minutes, followed by continuous infusion at 0.5 µg/kg/hr. At 8 minutes, 5 mL normal saline was administered.
- **Group F:** Received 20 mL normal saline infusion over 10 minutes, followed by continuous infusion. At 8 minutes, fentanyl 1 µg/kg diluted to 5 mL was administered.

Hemodynamic parameters were recorded at 2-minute intervals during drug infusion. Bradycardia (HR <45 bpm) was treated with atropine 0.6 mg IV.

Anesthesia Technique

Anesthesia was induced with propofol (titrated to loss of eyelash reflex) and atracurium 0.5 mg/kg. Laryngoscopy and endotracheal intubation were performed using a Macintosh laryngoscope.
Anesthesia was maintained with sevoflurane in 66% nitrous oxide and oxygen. Ventilation was adjusted to maintain $EtCO_2$ between 30–35 mmHg. Intra-abdominal pressure during pneumoperitoneum was maintained at 12–15 mmHg.

Data Collection (Hemodynamic Monitoring)

Hemodynamic parameters (HR, SBP, DBP, MAP) were recorded at:

- Baseline
- During infusion
- After intubation (1, 3, 5, 7, 10 minutes)
- At skin incision
- After pneumoperitoneum (1 minute)
- Every 5 minutes for 30 minutes
- Every 15 minutes thereafter until end of surgery
- During extubation and post-extubation period

Extubation and Postoperative Monitoring
Neuromuscular blockade was reversed using neostigmine and glycopyrrolate. Hemodynamic responses during extubation were recorded similarly to intubation.

Patients were monitored postoperatively in the PACU.

Outcome Measures
- **Primary Outcome:** Hemodynamic response (HR, SBP, DBP, MAP) to laryngoscopy, pneumoperitoneum, and extubation.
- **Secondary Outcomes:** Intraoperative hemodynamic stability and incidence of adverse events (bradycardia, hypotension).

Statistical Analysis
Data were analyzed using SPSS software (version 20). Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test. Categorical variables were analyzed using Chi-square test. A p-value <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics
A total of 40 patients were included and equally distributed into two groups (n=20 each). The mean age was comparable between Group D (37.3 ± 11.98 years) and Group F (42.4 ± 13.42 years) with no statistically significant difference (p > 0.05). Gender distribution was also similar between the groups (Group D: 11 males, 9 females; Group F: 12 males, 8 females), indicating that both groups were demographically comparable at baseline.

HEMODYNAMIC PARAMETERS

Table 1: Heart Rate (bpm) at Key Perioperative Time Points

Time Point	Group D (Mean ± SD)	Group F (Mean ± SD)	p-value
Baseline	78.0 ± 13.1	88.2 ± 9.4	0.007*
Intubation (1 min)	80.4 ± 12.3	90.9 ± 15.4	0.022*
Skin incision	76.6 ± 13.1	83.7 ± 10.5	0.066
Pneumoperitoneum (1 min)	77.1 ± 11.2	86.5 ± 11.3	0.012*
End of surgery	64.1 ± 9.7	70.3 ± 9.3	0.046*
Extubation (1 min)	70.1 ± 8.2	90.7 ± 11.9	<0.001*
Postoperative (30 min)	60.1 ± 9.2	81.4 ± 10.8	<0.001*

Heart rate was significantly lower in Group D compared to Group F at baseline (p = 0.007). Following intubation, both groups showed an increase in heart rate; however, the rise was significantly attenuated in Group D (p = 0.022). Although the difference at skin incision was not statistically significant (p = 0.066), Group F consistently showed higher values. During pneumoperitoneum, heart rate was significantly higher in Group F (p = 0.012). At the end of surgery, Group D maintained lower heart rates (p = 0.046). A marked increase was observed during extubation in both groups, but it was significantly greater in Group F (p < 0.001). Postoperatively, Group D demonstrated significantly lower heart rates (p < 0.001), indicating superior perioperative hemodynamic control with dexmedetomidine.

Table 2: Systolic Blood Pressure (mmHg) at Key Time Points

Time Point	Group D	Group F	p-value
Baseline	126.3 ± 13.2	136.8 ± 18.5	0.045*
Intubation (1 min)	129.3 ± 21.1	134.6 ± 21.9	0.444
Skin incision	116.5 ± 13.9	126.4 ± 15.4	0.039*
Pneumoperitoneum (1 min)	124.5 ± 11.3	136.8 ± 18.3	0.014*
End of surgery	105.9 ± 8.6	117.1 ± 13.5	0.004*
Extubation (1 min)	122.6 ± 14.2	150.2 ± 18.4	<0.001*
Postoperative (30 min)	111.9 ± 14.3	128.4 ± 13.8	0.001*

Baseline systolic blood pressure was significantly lower in Group D compared to Group F (p = 0.045). Following intubation, both groups exhibited an increase, but the difference was not statistically significant (p = 0.444). During skin incision and pneumoperitoneum, SBP was significantly higher in Group F (p = 0.039 and p = 0.014, respectively). At the end of surgery, Group D maintained significantly lower SBP values (p = 0.004). A pronounced rise in SBP was observed during extubation, with significantly higher values in Group F (p < 0.001). Postoperatively, SBP remained significantly lower in Group D (p = 0.001), reflecting better hemodynamic stability.

Table 3: Diastolic Blood Pressure (mmHg) at Key Time Points

Time Point	Group D	Group F	p-value
Baseline	78.3 ± 10.2	80.3 ± 11.0	0.564
Intubation (1 min)	87.5 ± 12.7	90.4 ± 17.2	0.548
Pneumoperitoneum (1 min)	83.4 ± 11.0	91.3 ± 12.0	0.037*
End of surgery	70.4 ± 10.9	76.6 ± 8.2	0.046*
Extubation (1 min)	82.8 ± 14.5	99.7 ± 14.5	<0.001*
Postoperative (30 min)	70.2 ± 9.3	83.0 ± 8.6	<0.001*

Baseline diastolic blood pressure was comparable between the groups (p = 0.564). Following intubation, both groups showed an increase without significant difference (p = 0.548). However, during pneumoperitoneum, DBP was significantly higher in Group F (p = 0.037). At the end of surgery, Group D had significantly lower DBP values (p = 0.046). During extubation, a significant rise in DBP was observed in both groups, with markedly higher values in Group F (p < 0.001). Postoperatively, DBP remained significantly lower in Group D (p < 0.001), indicating better control of diastolic pressure.

Table 4: Mean Arterial Pressure (mmHg) at Key Time Points

Time Point	Group D	Group F	p-value
Baseline	89.8 ± 8.5	92.8 ± 12.2	>0.05
Intubation (1 min)	97.3 ± 14.0	100.4 ± 17.4	NS
Pneumoperitoneum (1 min)	93.2 ± 11.2	101.1 ± 12.3	<0.05*
End of surgery	78.5 ± 9.6	85.7 ± 9.1	<0.05*
Extubation (1 min)	92.7 ± 14.3	111.2 ± 14.1	<0.001*
Postoperative (30 min)	79.2 ± 9.7	93.6 ± 9.1	<0.001*

Mean arterial pressure at baseline was comparable between the two groups (p > 0.05). Following intubation, MAP increased in both groups without a statistically significant difference. During pneumoperitoneum, MAP was significantly higher in Group F (p < 0.05). At the end of surgery, Group D maintained significantly lower MAP values (p < 0.05). A marked increase in MAP was observed during extubation, with significantly higher values in Group F (p < 0.001). In the postoperative period, MAP remained significantly lower in Group D (p < 0.001), suggesting superior attenuation of hemodynamic stress responses.

DISCUSSION

The present study evaluated the effectiveness of dexmedetomidine compared to fentanyl in attenuating perioperative hemodynamic responses to laryngoscopy, pneumoperitoneum, and extubation. The results demonstrated that dexmedetomidine provided significantly better control of heart rate and blood pressure responses at critical perioperative time points.

The baseline demographic characteristics, including age and gender distribution, were comparable between the two groups, ensuring homogeneity and validity of comparison. However, baseline heart rate was significantly lower in the dexmedetomidine group (78.0 ± 13.1 bpm) compared to the fentanyl group (88.2 ± 9.4 bpm, p = 0.007), suggesting an early sympatholytic effect of dexmedetomidine even before induction.

Following laryngoscopy and intubation, both groups exhibited an increase in heart rate and blood pressure, which is a well-recognized sympathetic response. However, the rise in heart rate at 1 minute post-intubation was significantly attenuated in the dexmedetomidine group (80.4 ± 12.3 vs 90.9 ± 15.4 bpm, p = 0.022). This finding is consistent with the study by Aho M et al (5), who reported significantly lower post-intubation heart rate increases with dexmedetomidine compared to fentanyl. Similarly, Scheinin B et al (17) demonstrated attenuation of cardiovascular responses to intubation with dexmedetomidine.

During pneumoperitoneum, which is associated with increased intra-abdominal pressure and sympathetic stimulation, the hemodynamic response was significantly higher in the fentanyl group. Heart rate (77.1 ± 11.2 vs 86.5 ± 11.3 bpm, p = 0.012), systolic blood pressure (124.5 ± 11.3 vs 136.8 ± 18.3 mmHg, p = 0.014), and diastolic blood pressure (83.4 ± 11.0 vs 91.3 ± 12.0 mmHg, p = 0.037) were all significantly lower in the dexmedetomidine group. These findings highlight the superior ability of dexmedetomidine to attenuate stress responses during pneumoperitoneum and are in agreement with Talke P et al (18), who reported reduced catecholamine levels and improved hemodynamic stability with dexmedetomidine. At the time of extubation, a marked increase in all hemodynamic parameters was observed in both groups; however, the rise was significantly greater in the fentanyl group. Heart rate (70.1 ± 8.2 vs 90.7 ± 11.9 bpm, p < 0.001), systolic blood pressure (122.6 ± 14.2 vs 150.2 ± 18.4 mmHg, p < 0.001), diastolic blood pressure (82.8 ± 14.5 vs 99.7 ± 14.5 mmHg, p < 0.001), and mean arterial pressure (92.7 ± 14.3 vs 111.2 ± 14.1 mmHg, p < 0.001) were all significantly lower in the dexmedetomidine group. These findings are comparable to the study by Mowafi HA et al (19), which demonstrated effective attenuation of hemodynamic responses with dexmedetomidine during airway manipulation.

At the end of surgery, dexmedetomidine continued to demonstrate better hemodynamic stability, with significantly lower heart rate (64.1 ± 9.7 vs 70.3 ± 9.3 bpm, $p = 0.046$) and systolic blood pressure (105.9 ± 8.6 vs 117.1 ± 13.5 mmHg, $p = 0.004$). In the postoperative period, this trend persisted, with significantly lower heart rate (60.1 ± 9.2 vs 81.4 ± 10.8 bpm, $p < 0.001$), systolic blood pressure (111.9 ± 14.3 vs 128.4 ± 13.8 mmHg, $p = 0.001$), diastolic blood pressure (70.2 ± 9.3 vs 83.0 ± 8.6 mmHg, $p < 0.001$), and mean arterial pressure (79.2 ± 9.7 vs 93.6 ± 9.1 mmHg, $p < 0.001$) in the dexmedetomidine group. This sustained effect can be attributed to reduced sympathetic outflow and catecholamine suppression, as also demonstrated by Aantaa RE et al (20) and Talke P et al (18).

The observed hemodynamic stability with dexmedetomidine may also contribute to reduced anesthetic and analgesic requirements. Scheinin B et al (17) reported decreased thiopentone and opioid requirements, while Tufanogullari B et al (21) demonstrated reduced volatile anesthetic and opioid use with dexmedetomidine infusion. Additionally, Keith A et al (7) reported reduced requirement for rescue sedatives and opioids with improved patient satisfaction and minimal respiratory depression.

However, dexmedetomidine is associated with adverse effects such as bradycardia and hypotension. In our study, a few patients in the dexmedetomidine group developed bradycardia requiring intervention, which is consistent with findings by Erkola O et al (22), who reported a higher incidence of bradycardia with dexmedetomidine. Similarly, Craig et al (23) noted an increased need for treatment of hypotension in the postoperative period with dexmedetomidine.

Dexmedetomidine has also been shown to be a suitable alternative to fentanyl for airway management. Uzumcugil F et al (24) demonstrated comparable conditions for laryngeal mask insertion with better preservation of respiratory function, further supporting its clinical utility.

Overall, the findings of the present study strongly support the use of dexmedetomidine as an effective agent for attenuating perioperative hemodynamic responses. Its ability to provide significant control over heart rate and blood pressure at critical time points, along with its sedative and analgesic-sparing properties, makes it a valuable adjunct in anesthetic practice.

CONCLUSION

Dexmedetomidine is more effective than fentanyl in attenuating perioperative hemodynamic responses to laryngoscopy, pneumoperitoneum, and extubation in patients undergoing laparoscopic surgeries. It provides significantly better control of heart rate and blood pressure at critical time points, including intubation, pneumoperitoneum, extubation, and the postoperative period.

In addition to superior hemodynamic stability, dexmedetomidine offers sustained sympatholytic effects, contributing to improved perioperative cardiovascular control. However, its use may be associated with bradycardia, necessitating careful monitoring and appropriate dose titration.

Overall, dexmedetomidine can be considered a valuable and effective alternative to fentanyl for achieving optimal perioperative hemodynamic stability in laparoscopic surgical procedures.

Conflict of interest: Nil

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