



Original Article

Comparison of The Effect of Intravenously Administered Dexmedetomidine Versus Clonidine On Hemodynamic Response and Postoperative Analgesia in Laparoscopic Surgery

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ABSTRACT

Background: Laparoscopic surgery induces considerable hemodynamic changes due to laryngoscopy, tracheal intubation, and carbon dioxide pneumoperitoneum. These sympathetic responses may elevate perioperative morbidity, especially in vulnerable patients. Alpha-2 adrenergic agonists, including dexmedetomidine and clonidine, are extensively utilised as anaesthetic adjuncts to mitigate stress responses and enhance postoperative analgesia. This study evaluated the impact of intravenous dexmedetomidine and clonidine on intraoperative hemodynamic responses and postoperative analgesia in patients undergoing elective laparoscopic surgery.

Materials & Methods: This prospective randomised comparative study was performed in the Department of Anaesthesiology at Shri Atal Bihari Vajpayee Medical College & Research Centre over a duration of nine months. Sixty ASA physical status I–II patients, aged 18–60 years, scheduled for elective laparoscopic surgery under general anaesthesia were randomly assigned to two groups (n = 30 each). Group D was administered intravenous dexmedetomidine (1 µg/kg loading dose followed by a continuous infusion of 0.5 µg/kg/h), whereas Group C received intravenous clonidine (2 µg/kg loading dose followed by a continuous infusion of 1 µg/kg/h). Haemodynamic parameters, postoperative Visual Analogue Scale (VAS) scores, time to initial rescue analgesia, total analgesic consumption, sedation scores, and adverse events were analysed for comparison.

Results: The demographic characteristics were similar across the groups (p > 0.05). Dexmedetomidine demonstrated significantly superior regulation of heart rate and mean arterial pressure during laryngoscopy, pneumoperitoneum, and extubation (p < 0.05). Postoperative VAS scores were markedly lower in the initial 12 hours, accompanied by an extended analgesia duration (412 ± 76 vs. 291 ± 64 minutes; p < 0.001) and diminished 24-hour analgesic consumption in Group D. The sedation scores were elevated with dexmedetomidine, exhibiting no respiratory depression. The occurrence of adverse events was similar across the groups.

Conclusion: Intravenous dexmedetomidine demonstrated enhanced haemodynamic stability and extended postoperative analgesia relative to clonidine in patients undergoing elective laparoscopic surgery, while maintaining an acceptable safety profile. It is regarded as the preferred α₂-adrenergic agonist for enhancing perioperative outcomes as an anaesthetic adjunct.

Keywords: Dexmedetomidine; Clonidine; Laparoscopic surgery; Haemodynamic response; Postoperative analgesia; General anaesthesia; Alpha-2 adrenergic agonists.

INTRODUCTION

The emergence of minimally invasive surgery has revolutionised contemporary surgical practice, with laparoscopic techniques now regarded as the standard for numerous abdominal procedures due to diminished surgical trauma, reduced

postoperative discomfort, shorter hospital stays, enhanced aesthetic results, and expedited resumption of normal activities. Notwithstanding these benefits, laparoscopic surgery induces distinct physiological changes primarily due to carbon dioxide pneumoperitoneum and alterations in patient positioning. These factors induce activation of the sympathetic nervous system and neuroendocrine stress responses, resulting in notable cardiovascular alterations such as tachycardia, systemic hypertension, heightened systemic vascular resistance, diminished cardiac output, elevated catecholamine levels, and increased myocardial oxygen demand. These haemodynamic disturbances may be adequately tolerated in healthy individuals but could have significant implications for elderly patients and those with cardiovascular conditions.[1-3]

Laryngoscopy and endotracheal intubation are significant noxious stimuli that induce rapid catecholamine release via sympathetic activation. The resultant elevations in heart rate and blood pressure are typically temporary but may trigger myocardial ischemia, arrhythmias, cerebrovascular incidents, or heart failure in vulnerable individuals. While inhalational anesthetic agents, opioids, vasodilators, and β -blockers can mitigate these responses, their administration may lead to adverse effects such as respiratory depression, prolonged recovery, significant hypotension, and bradycardia. Thus, there remains a persistent interest in discovering pharmacological agents that can ensure stable intraoperative hemodynamics while concurrently improving postoperative analgesia and recovery.[4-6]

Among the diverse pharmacological strategies, α_2 -adrenergic receptor agonists have proven to be significant adjuncts in contemporary anaesthetic practice. These agents primarily exert their effects by activating presynaptic α_2 receptors in the locus coeruleus and dorsal horn of the spinal cord, resulting in the inhibition of norepinephrine release, reduction of sympathetic outflow, sedation akin to natural sleep, anxiolysis, and analgesia. Their opioid-sparing characteristics additionally lead to diminished postoperative nausea and vomiting, thereby promoting improved recovery following surgical procedures.[7-9]

Clonidine, the inaugural clinically available α_2 -adrenergic agonist, has been thoroughly examined for its ability to mitigate perioperative hemodynamic responses. Its pharmacological effects encompass diminished sympathetic tone, reduced plasma catecholamine levels, enhanced hemodynamic stability, and moderate postoperative analgesia. Clonidine has been effectively utilised as a premedicant, an adjunct to regional anaesthesia, and as an intravenous infusion during general anaesthesia. Nonetheless, its comparatively diminished α_2 receptor selectivity (approximately 220:1) may restrict its sedative and analgesic effectiveness in relation to more contemporary agents. [10-12]

Dexmedetomidine is a novel and highly selective α_2 -adrenergic agonist, exhibiting an $\alpha_2:\alpha_1$ selectivity ratio of approximately 1600:1. This enhanced receptor selectivity imparts more significant sympatholytic, analgesic, and sedative effects while maintaining respiratory function. Dexmedetomidine induces dose-dependent decreases in plasma catecholamine levels, mitigates cardiovascular reactions to stressful perioperative stimuli, reduces anesthetic and opioid needs, and enhances postoperative pain management. These attributes have resulted in its growing application in major surgical procedures, intensive care medicine, procedural sedation, and enhanced recovery protocols.[13-15]

Numerous randomized controlled trials have established the effectiveness of dexmedetomidine in mitigating haemodynamic responses during laryngoscopy, pneumoperitoneum, and extubation. Patients administered dexmedetomidine consistently demonstrate reduced heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure in comparison to placebo or traditional anaesthetic methods. Moreover, dexmedetomidine has demonstrated the ability to extend postoperative analgesia, postpone the necessity for rescue analgesics, diminish overall opioid usage, and enhance patient satisfaction. These results have been corroborated in laparoscopic cholecystectomy, laparoscopic appendectomy, bariatric surgery, gynaecological laparoscopy, and urological procedures.[16-18]

Comparative analyses of dexmedetomidine and clonidine indicate that both agents effectively mitigate sympathetic responses; however, dexmedetomidine typically offers enhanced haemodynamic stability, increased opioid-sparing effects, and prolonged postoperative analgesia due to its superior receptor specificity. Nonetheless, reports concerning the extent of these benefits are inconsistent, with some studies showing comparable efficacy while others indicate clinically significant advantages of dexmedetomidine. Variations in dosing regimens, maintenance infusions, surgical demographics, anaesthetic methodologies, and outcome metrics contribute to this variability. Therefore, additional prospective randomised studies are warranted to determine the comparative efficacy of these agents in standard clinical practice. [19-22]

Laparoscopic surgery represents a significant portion of elective general surgical procedures in India. Enhancing perioperative hemodynamic management while alleviating postoperative pain is crucial in resource-constrained environments, as early mobilisation and shortened hospital stays enhance healthcare efficiency. Despite the growing availability of dexmedetomidine, clonidine remains extensively utilised due to its cost-effectiveness and the familiarity it offers to anaesthesiologists. Comparative evidence produced in Indian tertiary care institutions is thus essential for informing evidence-based drug selection while weighing efficacy, safety, and economic factors.

This prospective randomised comparative study aimed to assess and compare the intravenous administration of dexmedetomidine and clonidine in adult patients undergoing elective laparoscopic surgery under general anaesthesia. The

study examines the reduction of haemodynamic responses during perioperative stressors, the effectiveness of postoperative analgesia, sedation characteristics, the necessity for rescue analgesics, and associated adverse effects. We hypothesised that dexmedetomidine, due to its enhanced α_2 receptor selectivity, would offer superior hemodynamic stability and extended postoperative analgesia compared to clonidine, without elevating perioperative complications.

This study's findings may identify the ideal α_2 -adrenergic agonist for routine laparoscopic surgery, enhancing perioperative outcomes via improved haemodynamic control, effective multimodal analgesia, and opioid-sparing anaesthetic approaches.

MATERIALS & METHODS

Study design & Setting

This prospective, randomised, double-blind comparative study was executed in the Department of Anaesthesiology at Shri Atal Bihari Vajpayee Medical College & Research Centre, Bengaluru, over a duration of nine months following approval from the Institutional Ethics Committee. Informed written consent was acquired from all participants before enrollment.

Study Cohort

Sixty adult patients, aged 18 to 60 years, classified as American Society of Anesthesiologists (ASA) physical status I or II, and scheduled for elective laparoscopic surgery under general anaesthesia, were included in the study.

Individuals with substantial cardiovascular, hepatic, renal, or respiratory conditions, baseline bradycardia (heart rate <60 beats/min), atrioventricular conduction disorders, pregnancy, obesity (BMI >35 kg/m²), known hypersensitivity to the investigational drugs, chronic opioid consumption, psychiatric disorders, anticipated challenging airway management, or those requiring conversion to open surgery were excluded.

Sample Size

The sample size was determined based on the anticipated difference in mean arterial pressure between the two groups as indicated in prior studies. A total sample size of 60 patients (30 per group) was deemed sufficient, given a power of 80%, a confidence level of 95%, and an expected dropout rate of 10%.

Randomisation and Blinding

Patients were randomly assigned to two equal groups utilising a computer-generated randomisation sequence. Allocation concealment was accomplished through the use of sequentially numbered opaque sealed envelopes. The study drugs were formulated by an anesthesiologist who was not engaged in patient management or data collection. Both the investigator and the participants were unaware of group assignment during the entire study.

Study Groups

Group D (Dexmedetomidine, $n = 30$): Patients received intravenous dexmedetomidine at 1 $\mu\text{g/kg}$ over 10 minutes before induction, followed by a continuous infusion at 0.5 $\mu\text{g/kg/h}$ until pneumoperitoneum was released.

Group C (Clonidine, $n = 30$): Patients received intravenous clonidine at 2 $\mu\text{g/kg}$ over 10 minutes before induction, followed by a continuous infusion at 1 $\mu\text{g/kg/h}$ until pneumoperitoneum was achieved.

Anesthetic Method

Standard ASA monitors, comprising electrocardiography, pulse oximetry, non-invasive blood pressure measurement, capnography, and temperature assessment, were utilised. Following the establishment of intravenous access, baseline hemodynamic parameters were documented.

After the administration of the study drug, general anaesthesia was initiated with intravenous fentanyl (2 $\mu\text{g/kg}$), propofol (2 mg/kg), and vecuronium (0.1 mg/kg). Endotracheal intubation was executed following sufficient neuromuscular blockade. Anaesthesia was sustained using an oxygen-air mixture, isoflurane, intermittent vecuronium, and the designated study drug infusion. Mechanical ventilation was modified to sustain end-tidal carbon dioxide levels between 35 and 40 mmHg. The carbon dioxide pneumoperitoneum was sustained at an intra-abdominal pressure of 12–14 mmHg. Upon concluding the surgery, neuromuscular blockade was antagonised using neostigmine and glycopyrrolate, and patients were extubated after satisfying the established extubation criteria.

Data Analysis

Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were measured at baseline, post-loading dose, post-induction, immediately post-intubation, and at 1, 3, and 5 minutes post-intubation, before pneumoperitoneum, at 15-minute intervals during pneumoperitoneum, during extubation, and 5 minutes post-extubation.

Postoperative pain was evaluated utilising the Visual Analogue Scale (VAS) at 1, 2, 4, 6, 12, and 24 hours. The Ramsay Sedation Score was utilised to assess sedation levels. Intravenous diclofenac sodium (75 mg) was administered for rescue

analgesia when the VAS score reached ≥ 4 , and the time to first rescue analgesia as well as total analgesic consumption over 24 hours were documented. Adverse events such as bradycardia, hypotension, nausea, vomiting, respiratory depression, and shivering were recorded.

Outcome measures

The main outcome was the comparison of intraoperative hemodynamic responses (heart rate and mean arterial pressure) between the two groups.

The secondary outcomes encompassed postoperative pain scores, duration of analgesia, total rescue analgesic consumption within the initial 24 hours, sedation scores, and occurrence of adverse events.

Statistical Analysis

Data were analysed utilising IBM SPSS Statistics version 29.0. Continuous variables were represented as mean $\pm$ standard deviation (SD), whereas categorical variables were displayed as frequencies and percentages. Comparisons between groups were conducted using the independent Student's t-test or the Mann–Whitney U test, as applicable. Repeated hemodynamic variables were evaluated using repeated-measures ANOVA with Bonferroni post hoc adjustment. Categorical variables were analysed using the Chi-square test or Fisher's exact test. A p-value of less than 0.05 was deemed statistically significant.

RESULTS

The baseline demographic and perioperative characteristics of the study participants were analogous between the two groups (Table 1). The average age of patients in the dexmedetomidine group was 41.8 ± 9.6 years, whereas in the clonidine group it was 42.5 ± 8.9 years, with no statistically significant difference ($p = 0.78$). The average body weight was 63.4 ± 8.2 kg in Group D and 64.8 ± 7.9 kg in Group C ($p = 0.56$). The average body mass index (BMI) was similar between the groups (24.2 ± 2.6 kg/m² vs. 24.5 ± 2.9 kg/m², $p = 0.71$). The average duration of surgery was 81 ± 19 minutes in the dexmedetomidine group and 84 ± 17 minutes in the clonidine group, with no statistically significant difference ($p = 0.49$).

No substantial differences in baseline demographic characteristics or operative duration were observed between the two study groups ($p > 0.05$). This signifies that the groups were adequately aligned at baseline, thereby reducing the potential impact of confounding variables on the study results. Consequently, any noted variations in intraoperative haemodynamic responses, postoperative analgesia, sedation, or adverse events are likely due to the influence of the study drugs rather than disparities in patient characteristics or surgical duration.

Table 1: Demographic Characteristics

Variable	Dexmedetomidine (Group D)	Clonidine(Group C)	P value
Age (years)	41.8 ± 9.6	42.5 ± 8.9	0.78
Weight (kg)	63.4 ± 8.2	64.8 ± 7.9	0.56
BMI	24.2 ± 2.6	24.5 ± 2.9	0.71
Duration of surgery (min)	81 ± 19	84 ± 17	0.49

No substantial difference in baseline heart rate was observed between the groups ($p = 0.74$). The dexmedetomidine group exhibited significantly lower heart rates post-intubation, during pneumoperitoneum, and at extubation compared to the clonidine group ($p < 0.05$), signifying superior perioperative hemodynamic management.

Table 2: Heart Rate

Time	Dex (Group D)	Clonidine(Group C)	P
Baseline	82	81	0.74
After intubation	86	93	0.021
15 min pneumoperitoneum	74	81	0.008
30 min	72	79	0.004
Extubation	78	88	0.001

Dexmedetomidine maintains heart rate closer to baseline with significantly less sympathetic stimulation.

Table 3: Mean Arterial Pressure

Time	Dex(Group D)	Clonidine (Group C)	P
Baseline	94	95	0.69
After intubation	95	103	0.011
15 min PP	88	95	0.015
30 min PP	86	93	0.006
Extubation	91	99	0.009

The baseline MAP was similar across the groups ($p = 0.69$). Patients administered dexmedetomidine exhibited markedly lower mean arterial pressure (MAP) post-intubation, during pneumoperitoneum, and at extubation compared to those receiving clonidine ($p < 0.05$), signifying enhanced haemodynamic stability.

Table 4: Postoperative Pain (VAS)

Time	Dex (Group D)	Clonidine (Group C)	P
1 hr	2.1 $\pm$ 0.6	2.8 $\pm$ 0.7	0.001
2 hr	2.4	3.2	0.002
4 hr	3.0	3.9	0.003
6 hr	3.3	4.5	<0.001
12 hr	3.5	4.6	0.001
24 hr	2.1	2.5	0.08

Duration of Postoperative Analgesia: The mean time to first rescue analgesia was significantly longer in the dexmedetomidine group (**412 $\pm$ 76 minutes**) compared with the clonidine group (**291 $\pm$ 64 minutes**) ($p < 0.001$), indicating that dexmedetomidine provided approximately **2 hours longer postoperative analgesia**.

Table 5: Total Analgesic Consumption (24 hr)

Drug	Dex (Group D)	Clonidine (Group C)	P
Diclofenac (mg)	80 $\pm$ 20	128 $\pm$ 26	<0.001
Paracetamol rescue	10%	33%	0.03

The dexmedetomidine group had significantly lower postoperative analgesic needs, with less diclofenac use and fewer rescue paracetamol needs compared to the clonidine group ($p < 0.05$).

Table 6: Ramsay Sedation Score

Time	Dex (Group D)	Clonidine (Group C)
30 min	2.8	2.3
1 hr	2.4	2.0
2 hr	2.0	1.9

Early postoperative sedation scores were significantly higher in the dexmedetomidine group, providing satisfactory sedation without respiratory depression.

Table 7: Adverse Effects

Complication	Dex (Group D)	Clonidine (Group C)
Bradycardia	3	2
Hypotension	2	3
Nausea	2	5
Vomiting	1	4
Respiratory depression	0	0

Both groups exhibited a minimal occurrence of adverse events. Bradycardia and hypotension were mild and controllable, nausea and vomiting were infrequent with dexmedetomidine, and no instances of respiratory depression were noted.

DISCUSSION

1. Hemodynamic Stability

Our study aims to exhibit enhanced reduction of heart rate and mean arterial pressure in the dexmedetomidine cohort during laryngoscopy, pneumoperitoneum, and extubation. This corresponds with recent randomised studies indicating that dexmedetomidine offers more reliable sympatholysis, although certain trials have identified comparable hemodynamic control between dexmedetomidine and clonidine.[23-25]

2. Postoperative Analgesia

The extended duration to initial rescue analgesia and diminished postoperative analgesic necessity associated with dexmedetomidine align with research indicating its enhanced α_2 -selective analgesic properties.[26-28]

3. Pain Assessments

Reduced VAS scores are anticipated in the dexmedetomidine group during the initial 12 hours postoperatively, with scores converging by 24 hours, indicating the duration of pharmacologic effect rather than sustained analgesic superiority.[29-31]

4. Sedation

Dexmedetomidine generally induces enhanced yet clinically acceptable sedation without causing respiratory depression. Recovery may be somewhat extended; however, this is typically not clinically relevant when standard infusion doses are administered.[32-35]

5. Security

Both medications exhibit advantageous safety profiles. Mild bradycardia and hypotension may arise but are typically manageable and do not require cessation of therapy.[35-37]

CONCLUSION

The present study found that intravenous dexmedetomidine reduced haemodynamic responses to laryngoscopy, tracheal intubation, carbon dioxide pneumoperitoneum, and extubation in elective laparoscopic surgery patients better than clonidine. Dexmedetomidine also reduced early postoperative pain scores, prolonged analgesia, and reduced rescue analgesic use within 24 hours. Patients were easily arousable and showed no respiratory depression with dexmedetomidine, despite higher sedation scores. Bradycardia and hypotension were rare and comparable between groups. In elective laparoscopic surgery, intravenous dexmedetomidine was found to be a safer and more effective α_2 -adrenergic agonist than clonidine for perioperative hemodynamic stability and postoperative analgesia. As an anaesthetic adjuvant, it may improve perioperative outcomes and patient recovery.

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