Original Research Article

COMPARATIVE EVALUATION OF INTRAVENOUS LABETALOL, DEXMEDETOMIDINE AND LIGNOCAINE FOR ATTENUATION OF HEMODYNAMIC RESPONSE TO PNEUMOPERITONEUM: A RANDOMIZED CONTROLLED STUDY

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Abstract

Background and Objective:

Laparoscopic cholecystectomy, though minimally invasive, is associated with significant hemodynamic stress responses due to pneumoperitoneum and anaesthetic interventions. Effective attenuation of these responses is crucial, particularly in patients with cardiovascular risks. This study compares the efficacy of intravenous labetalol, dexmedetomidine, and lignocaine in controlling these responses.

Material and Methods:

In this prospective, randomized controlled study, 150 ASA I–II normotensive patients aged 16–60 years undergoing elective laparoscopic cholecystectomy under general anaesthesia were randomized into three groups (n = 50 each). Group L received labetalol 0.25 mg/kg in 200 ml NS over 10 minutes before induction, Group D received dexmedetomidine 0.5 μg/kg in 200 ml NS over 10 minutes before induction, and Group Lox received lignocaine 1.5 mg/kg as bolus 3 minutes before induction. Hemodynamic parameters (HR, SBP, DBP, MAP) were recorded at baseline, induction, laryngoscopy, and at 3-minute intervals up to 30 minutes post-intubation.

Results:

Dexmedetomidine demonstrated the most consistent and significant control of heart rate and blood pressure throughout the intraoperative period. Labetalol effectively maintained blood pressure but was less effective in controlling heart rate. Lignocaine showed moderate efficacy in attenuating hemodynamic responses. Adverse events were minimal: hypotension occurred in 2% of patients in Group L, and bradycardia occurred in 10% of Group D. No adverse events were noted in Group Lox.

Conclusion:

Dexmedetomidine was superior in maintaining hemodynamic stability during laparoscopic cholecystectomy, with labetalol serving as an effective alternative for blood pressure control. Lignocaine, while safe, was less effective in managing acute hemodynamic fluctuations. Dexmedetomidine may be preferred in patients at risk of exaggerated sympathetic responses.

Keywords:

Hemodynamic response, Laparoscopic cholecystectomy, Pneumoperitoneum

Introduction

Advancements in surgery and anaesthesia, including the adoption of minimally invasive techniques and faster-acting drugs, have made day care surgeries like laparoscopic cholecystectomy increasingly common. This procedure offers numerous benefits over open surgery, such as reduced postoperative pain, shorter hospital stays, faster recovery, and fewer complications like ileus.[1]

However, laparoscopic cholecystectomy, typically performed under general anaesthesia, is associated with significant haemodynamic stress responses due to laryngoscopy, intubation, and pneumoperitoneum. The insufflation of carbon dioxide to create pneumoperitoneum raises intra-abdominal pressure (IAP), leading to systemic effects:

- Cardiovascular: IAP <15 mmHg may increase cardiac output via splanchnic autotransfusion, whereas IAP >15 mmHg can reduce venous return and cardiac output. Vagal stimulation can also trigger bradyarrhythmias or cardiac arrest.[2,3]
- Respiratory: Elevated IAP reduces lung volumes and increases airway pressures.[4]
- Neurological: Hypercapnia and elevated intra-abdominal pressures may raise intracranial pressure, compromising cerebral perfusion.[5]
- Positioning: Head-up tilt lowers venous return and BP, while head-down improves preload but may impair ventilation.[6]

These transient but unpredictable haemodynamic changes are generally well tolerated in healthy patients but pose a risk in those with cardiovascular comorbidities. Therefore, blunting the stress response is crucial to ensure intraoperative stability and improve outcomes.

Various pharmacological agents such as beta blockers, opioids, calcium channel blockers, benzodiazepines, and alpha-2 agonists are used to attenuate these responses.[7] However, each has limitations, and no single agent has proven ideal. This study aims to compare the efficacy of intravenous labetalol, dexmedetomidine, and lignocaine in attenuating the haemodynamic response to pneumoperitoneum during laparoscopic cholecystectomy.

Material and Methods

After obtaining ethical committee clearance, this prospective, randomized controlled study was conducted in the Department of Anaesthesia at Government Medical College, Rajindra Hospital, Patiala. A total of 150 ASA I–II normotensive patients aged 16–60 years undergoing elective laparoscopic surgery under general anaesthesia were enrolled and randomized into three equal groups (n = 50) using the closed-envelope method.

Sample size was calculated to detect a mean heart rate difference of 6.9 bpm with a standard deviation of 12.3, 95% confidence interval, 80% power, and $\alpha = 0.05$, resulting in 50 patients per group.

- Group L received IV labetalol 0.25 mg/kg in 200 ml normal saline over 10 minutes before induction.
- Group D received IV dexmedetomidine 0.5 µg/kg in 200 ml normal saline over 10 minutes.
- Group Lox received IV lignocaine 2% 1.5 mg/kg as a bolus 3 minutes prior to induction.

Patients were preloaded with 10 ml/kg of crystalloid and monitored with ECG, NIBP, and SpO_2. Standard premedication included glycopyrrolate 4 µg/kg and butorphanol 20 µg/kg. Anaesthesia was induced with propofol 1.5 mg/kg and succinylcholine 1.5 mg/kg, and maintained with isoflurane, nitrous oxide, oxygen, and vecuronium.

Hemodynamic parameters (HR, SBP, DBP, MAP, SpO_2, $EtCO_2$) were recorded at baseline (T0), at induction (Ti), laryngoscopy (TL), and every 3rd minute up to 30th minute post-intubation. In Groups L and D, values were also recorded every 2 minutes during the 10-minute infusion period. Hypotension or bradycardia (≥20% decrease from baseline) was noted and treated accordingly.

Statistical Analysis

Data were analyzed using descriptive statistics (mean, SD, median, and percentages) and inferential tests. Categorical variables were compared using the Chi-square test, while differences between group means were assessed using one-way ANOVA, followed by Tukey's post-hoc test for multiple comparisons. Paired t-tests were used for within-group pre- and post-intervention comparisons. A p-value < 0.05 was considered statistically significant.

Results

This study compared demographic and preoperative characteristics (age, gender, weight, ASA status) across

three intervention groups (L, D, Lox) undergoing laparoscopic cholecystectomy. No significant differences were found, indicating comparable baseline profiles and minimizing selection bias as indicated in Table 1

Table1: Demographic Data

Parameter	Group L (n=50)	Group D (n=50)	Group Lox (n=50)	p-value (Overall)
Age (years)	42.72 ± 12.32	40.90±12.08	39.74±11.02	>0.05 (NS)
Gender (% Female)	84%	82%	74%	>0.05 (NS)
Weight (kg)	63.28±6.91	64.02±7.26	63.38±5.67	>0.05 (NS)
ASA Grade I (%)	86%	82%	92%	>0.05 (NS)
ASA Grade II (%)	14%	18%	8%	>0.05 (NS)

Time of Creation of Pneumoperitoneum (Pn)-

Table2: Demographic Data

Time (Pn)	Group L		Group D		Group Lox		Overall	p value		
	Patients	%	Patients	%	Patients	%		L vs D	L vs Lox	D vs lox
T6	2	4%	1	2%	1	2%	0.341 (χ^2= 2.151) NS	0.935 (χ^2= 3.617) NS	0.397 (χ^2= 9.449) NS	0.988 (χ^2=2. 2.213) NS
T9	7	14%	7	14%	3	6%				
T12	38	76%	36	72%	41	82%				
T15	3	6%	6	12%	5	10%				
Total	50	100%	50	100%	50	10%				

Table 2 shows that in our study, the number of patients in whom pneumoperitoneum was established at 6, 9, 12, and 15 minutes after laryngoscopy were as follows: 2, 7, 38, and 3 in Group L; 1, 7, 36, and 6 in Group D; and 1, 3, 41, and 5 in Group Lox. There was no statistically significant difference in the timing of pneumoperitoneum in three groups (p>0.05) and in majority of patients pneumoperitoneum was created at 12th minute after induction.

Comparison of Vitals at T12 (Pneumoperitoneum)

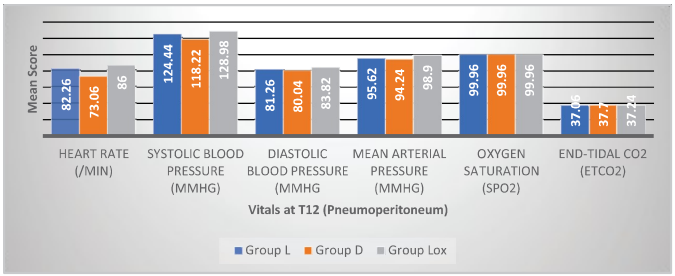
Table 3: Comparison of Vitals at T12 (Pneumoperitoneum)

	Group L	Group D	Group Lox	Overall	p value		
					L vs D	L vs Lox	D vs lox
Heart Rate (/min)	82.26±7.50	73.06±7.78	86.00±9.37	0.001 (F=32.527) HS	0.001 (t=6.020) HS	0.030 (t=2.205) S	0.001 (t=7.514) HS
Systolic BP (mmHg)	124.44±11.02	118.22±8.83	128.98±8.57	0.001 (F=16.039) HS	0.002 (t=3.114) S	0.024 (t=2.300) HS	0.001 (t=6.184) HS
Diastolic BP (mmHg	81.26±7.78	80.04±7.53	83.82±6.50	0.033 (F=3.499) S	0.428 (t=0.797) NS	0.077 (t=1.784) NS	0.008 (t=2.687) S
Mean Arterial Pressure (mmHg)	95.62±8.20	94.24±7.70	98.90±6.88	0.008 (F=4.944) S	0.388 (t=0.867) NS	0.033 (t=2.167) S	0.002 (t=3.193) S
Oxygen Saturation (Spo2)	99.96±0.20	99.96±0.20	99.96±0.20	0.816 (F=0.203) NS	1.000 (t=0.000) NS	0.562 (t=0.581) NS	0.562 (t=0.581) NS
End-tidal CO2 (EtCO2)	37.06±2.21	37.70±2.25	37.24±2.51	0.368 (F=1.005) NS	0.154 (t=1.435) NS	0.704 (t=0.381) NS	0.337 (t=0.964) NS

At the 12th minute (T12) post-pneumoperitoneum, dexmedetomidine (Group D) demonstrated significantly better control of heart rate (73.06 ± 7.78 bpm) compared to labetalol (82.26 ± 7.50 bpm) and lignocaine (86.00 ± 9.37 bpm) (p = 0.001). Systolic blood pressure was also significantly lower in Group D (118.22 ± 8.83 mmHg) than in Group L (124.44 ± 11.02 mmHg) and Group Lox (128.98 ± 8.57 mmHg) (p = 0.001).

For diastolic BP, Group D (80.04 ± 7.53 mmHg) showed significantly lower values than Group Lox (83.82 ± 6.50 mmHg) (p = 0.008), though differences with Group L were not significant. Mean arterial pressure (MAP) was lowest in the dexmedetomidine group (94.24 ± 7.70 mmHg), followed by labetalol (95.62 ± 8.20 mmHg), and highest in the lignocaine group (98.90 ± 6.88 mmHg), with a statistically significant overall difference (p = 0.008). Notably, MAP differences were significant between Group D and Group Lox (p = 0.002) and Group L and Group Lox (p = 0.033), but not between Group L and Group D.

SpO_2 remained stable at 99.96 ± 0.20% across all groups (p = 0.816), and $EtCO_2$ showed no significant variation (p = 0.368), confirming no adverse respiratory effects of the study drugs during pneumoperitoneum.



Comparison of Vitals at T12 (Pneumoperitoneum)

Discussion

Laparoscopic cholecystectomy is a widely performed surgical procedure associated with minimal invasiveness, shorter hospital stays, and faster recovery.

However, it is not without its physiological challenges, particularly during the creation of pneumoperitoneum. The insufflation of carbon dioxide (CO_2) into the peritoneal cavity leads to an increase in intra-abdominal pressure, which, in turn, stimulates the sympathetic nervous system. This sympathetic surge can result in significant hemodynamic changes such as tachycardia, hypertension, and increased systemic vascular resistance. These effects are generally well tolerated in healthy individuals but may pose serious risks in patients with underlying cardiovascular disease, such as coronary artery disease, hypertension, or arrhythmias.

In this context, pre-emptive pharmacological modulation of the autonomic response becomes essential to enhance intraoperative stability and improve patient outcomes. The present study was designed to compare the efficacy of three pharmacologic agents—dexmedetomidine, labetalol, and lignocaine—in attenuating the hemodynamic responses to pneumoperitoneum during laparoscopic cholecystectomy. Each of these drugs exerts its effects through distinct mechanisms, which were reflected in their differing hemodynamic profiles observed in this study.

Dexmedetomidine:

Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, demonstrated the most effective attenuation of both heart rate (HR) and blood pressure (BP) responses in our study. Even at a lower dose of 0.5 µg/kg, it consistently maintained stable haemodynamics throughout the perioperative period. This can be attributed to its central sympatholytic action, which results in decreased norepinephrine release and blunted stress response. Additionally, its sedative, anxiolytic, and analgesic properties contribute to overall hemodynamic stability by reducing perioperative anxiety and nociceptive stimuli.

The findings of this study align with those reported by Gaiwal et al. (2025), Bhutia and Rai (2017), and Alam et al. (2023), who noted similar improvements in intraoperative haemodynamics and postoperative recovery parameters with dexmedetomidine administration.[8,10] Moreover, the 10% incidence of bradycardia in our dexmedetomidine group is consistent with previously reported rates in the literature, such as Basar et al. (2008) and Kewalramani et al. (2016), where similar dosing regimens were used.[14,7] While bradycardia may be viewed as a side effect, in many cases it reflects the desired reduction in sympathetic tone and is easily manageable with appropriate monitoring and intervention.

Labetalol:

Labetalol, a mixed α- and β-adrenergic antagonist, was effective in maintaining systolic and diastolic blood pressure but was comparatively less effective in controlling heart rate fluctuations. Its pharmacodynamic profile—blocking β1 and β2 receptors in combination with selective α1 antagonism—results in decreased peripheral vascular resistance and moderate reductions in cardiac output. These effects make it particularly suitable for patients with labile or borderline hypertension.

In our study, labetalol provided stable hemodynamic parameters with only a 2% incidence of hypotension, and no reports of bradycardia or arrhythmias. These findings reinforce the safety and utility of labetalol at a dose of 0.25 mg/kg. Similar observations were made by Singla et al. (2019), who advocated the use of labetalol in patients where blood pressure control was paramount, especially those with borderline or established hypertension.[11]

Lignocaine:

Lignocaine, primarily known as a local anaesthetic and antiarrhythmic agent, has gained interest in recent years for its systemic effects when administered intravenously. Its mechanism involves sodium channel blockade, which can stabilize neuronal membranes and attenuate the transmission of pain signals and stress responses. Additionally, lignocaine has mild sympatholytic and anti-inflammatory properties that may contribute to intraoperative hemodynamic modulation and postoperative pain relief.

In the present study, lignocaine demonstrated moderate effectiveness in attenuating intraoperative stress responses. It was less efficacious than both dexmedetomidine and labetalol in suppressing acute elevations in HR and BP. These findings are consistent with those of Karan et al. (2021) and Hegazy et al. (2019), who also reported modest hemodynamic benefits and enhanced postoperative comfort following lignocaine infusion.[12,13]

Clinical Implications and Risk-Benefit Considerations:

The comparative analysis of these three agents offers important clinical insights. Dexmedetomidine, though associated with a higher incidence of bradycardia,

provided the most comprehensive attenuation of the hemodynamic stress response and may be especially beneficial in patients where both HR and BP control are critical. However, it requires close intraoperative monitoring due to its potent sympatholytic effect.

Labetalol emerges as a useful agent in scenarios where hypertension is the primary concern, especially in patients with preserved cardiac function and minimal risk of bradycardia. Its dual α- and β-blocking activity allows for effective BP control without significant cardiac depression at lower doses.

Lignocaine, although less potent in immediate hemodynamic modulation, demonstrated value through its analgesic benefits and exceptional safety profile. It may be particularly beneficial as an adjunct in multimodal analgesia or in patients who cannot tolerate β-blockers or α2-agonists.

Limitations and Future Directions:

While the findings of this study provide valuable insights, certain limitations must be acknowledged. The sample size, while adequate for detecting significant differences in primary outcomes, may not fully capture the variability in patient responses, especially in subgroups with severe comorbidities. Additionally, the duration of follow-up was limited to the intraoperative and immediate postoperative period; future studies may explore long-term outcomes such as postoperative recovery time, pain scores, and incidence of complications like nausea, vomiting, or delayed emergence.

Further research should also investigate optimal dosing strategies, combination therapies, and patient-specific factors (e.g., age, comorbidities, and ASA status) that may influence the choice of agent. Multicentric trials with larger populations would help validate these findings and contribute to more individualized perioperative care protocols.

Conclusion:

Among the agents studied, dexmedetomidine demonstrated superior efficacy in attenuating the hemodynamic responses to pneumoperitoneum during laparoscopic cholecystectomy, offering consistent control of heart rate and blood pressure with a favourable safety profile. Labetalol effectively maintained blood pressure with minimal adverse effects, making it a suitable alternative. Lignocaine, while safe and beneficial for postoperative analgesia, was less effective in controlling intraoperative hemodynamic fluctuations. These findings support the use of dexmedetomidine as a preferred agent for hemodynamic stability in laparoscopic procedures, particularly in patients at risk of exaggerated sympathetic responses.

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