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Original Research Article

Efficacy of Oral Atenolol as Premedication for Attenuating Hemodynamic Responses in Patients Undergoing Laparoscopic Cholecystectomy: A Double-Blind Randomized Controlled Trial

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Abstract:

Background: The gold standard for treating symptomatic cholelithiasis, laparoscopic cholecystectomy, is associated with significant hemodynamic fluctuations due to pneumoperitoneum and intubation stress. Atenolol, a selective beta-1 blocker, may attenuate these changes.

Objective: To assess how well oral atenolol premedication attenuates perioperative hemodynamic responses in laparoscopic cholecystectomy.

Methods: At Rajendra Institute of Medical Sciences in Ranchi, 100 ASA I–II patients between the ages of 30 and 60 participated in a prospective, double-blind, randomized controlled trial. Two sets of participants were randomly assigned to receive oral atenolol (50 mg) in Group A and a placebo in Group B. Heart rate (HR), systolic and diastolic blood pressures, and mean arterial pressure (MAP) were measured at baseline, after intubation, and five to sixty minutes following pneumoperitoneum.

Results: Atenolol significantly attenuated increases in HR, SBP, DBP, and MAP compared to placebo ($p < 0.001$ at most time points). No significant adverse events were noted.

Conclusion: Oral atenolol (50 mg) administered preoperatively is effective and safe in reducing hemodynamic fluctuations during laparoscopic cholecystectomy. It may be recommended as a cost-effective premedication to improve perioperative cardiovascular stability.

Introduction

Laparoscopic cholecystectomy is now firmly established as the treatment of choice for gallbladder stones and related disorders. Compared with the traditional open procedure, it offers clear benefits such as smaller incisions, reduced postoperative discomfort, quicker discharge, and early return to normal activity. Despite these advantages, the laparoscopic approach brings its own set of anesthetic challenges. The creation of carbon dioxide pneumoperitoneum and changes in posture during surgery can trigger major shifts in cardiovascular and respiratory physiology. Furthermore, laryngoscopy and endotracheal intubation produce a strong sympathetic response, which, when combined with elevated intra-abdominal pressure and hypercarbia, can cause significant rises in heart rate and blood pressure. While these changes may be tolerated by young, healthy individuals, they can provoke myocardial ischemia, arrhythmias, or circulatory instability in patients with limited cardiovascular reserve. For this reason, controlling such stress responses remains an important objective for anesthetic management during laparoscopic cholecystectomy.

Numerous pharmacological agents have been studied to blunt these hemodynamic surges. Opioids such as fentanyl and remifentanil are effective but may lead to prolonged recovery, respiratory depression, and postoperative nausea. Intravenous induction agents like propofol can reduce pressor

responses, yet their effect is too short to span the duration of surgery. Vasodilators such as nitroglycerin and sodium nitroprusside lower arterial pressure but frequently provoke compensatory tachycardia. Alpha-2 adrenergic agonists including clonidine and dexmedetomidine combine sedation with sympatholysis, but their tendency to produce hypotension or bradycardia and their relatively high cost limit everyday use, especially in resource-limited settings. The search therefore continues for a drug that is inexpensive, easy to administer, and able to maintain cardiovascular stability consistently throughout laparoscopic procedures.

Beta-adrenergic blockers provide a logical solution by directly counteracting catecholamine-driven sympathetic activity. Atenolol, a selective β1 receptor antagonist, lowers heart rate, myocardial contractility, and oxygen demand while sparing β2-mediated bronchodilation, which makes it safer in patients with airway reactivity. Its pharmacological profile is well suited for preoperative use: oral absorption is adequate, the half-life ranges between 6 and 9 hours, and the duration of action comfortably covers the operative period. Compared with short-acting intravenous β-blockers such as esmolol, atenolol is inexpensive, widely available, and convenient to administer in oral form. Previous research has shown that perioperative β-blockade reduces the incidence of myocardial ischemia and arrhythmias in high-risk surgical patients, but its value in routine laparoscopic cholecystectomy has not been examined extensively.

The purpose of this study was to assess whether premedication with oral atenolol can effectively dampen the hemodynamic responses to intubation and pneumoperitoneum during laparoscopic cholecystectomy. A prospective randomized double-blind trial was conducted to compare atenolol with placebo, with HR and BP parameters as primary outcomes. By generating high-quality data in this common surgical setting, we aim to clarify whether atenolol offers a practical, safe, and low-cost strategy for anesthesiologists to enhance cardiovascular stability during laparoscopic surgery.

Materials and Methods

Study Design & Setting: At Rajendra Institute of Medical Sciences in Ranchi, a prospective, double-blind, randomized controlled trial.

Trial Registration: CTRI/2024/01/061951.

Sample Size: 100 patients (50 per group), calculated based on previous studies with 80% power and 5% significance.

Eligibility:

- **Inclusion:** Patients aged 30–60 years, ASA I–II, BMI 18–24.
- **Exclusion:** Atenolol contraindication, acute cholecystitis, cardiorespiratory disease, anticipated difficult airway.

Randomization: Computer-generated sequence with sealed envelope method.

Interventions:

- Group A: Oral atenolol 50 mg with water.
- Group B: Oral vitamin placebo.

Premedication included ranitidine and metoclopramide. Propofol and rocuronium were used to produce anesthesia, which was maintained with O_2/N_2O/isoflurane. Pneumoperitoneum was created at 12–14 mmHg.

Outcome Measures: HR, SBP, DBP, MAP recorded at baseline, post-intubation, and at 5, 15, 30, 45, 60 minutes post-insufflation.

Statistical Analysis: SPSS v22. Continuous variables analyzed by t-test/ANOVA; categorical by Chi-square. Significance set at $p < 0.05$.

Results

Demographic Characteristics: Both groups were comparable in baseline characteristics such as sex, height, and weight ($p > 0.05$). However, the placebo group was slightly older on average, though this difference was not clinically significant.

Table 1: Baseline characteristics of study participants

Parameter	Atenolol Group (n=50)	Placebo Group (n=50)	p-value
Age (years, mean ± SD)	41.6 ± 7.4	44.8 ± 6.9	0.001*
Sex (M/F)	18 / 32	20 / 30	0.65
Weight (kg)	56.2 ± 8.1	55.7 ± 7.9	0.78
Height (cm)	161.4 ± 6.8	162.1 ± 7.0	0.56

*Statistically significant

Hemodynamic Parameters

Heart Rate (HR): At baseline, heart rates were similar between groups. Following intubation and during pneumoperitoneum, the placebo group demonstrated a significant rise in HR, while the atenolol group maintained stable values.

Blood Pressure (SBP, DBP, MAP): Systolic, diastolic, and mean arterial pressures increased sharply after pneumoperitoneum in the placebo

group. In contrast, the atenolol group showed only minimal changes, with differences between groups reaching statistical significance at most time points ($p < 0.001$).

Table 2: Comparison of intraoperative hemodynamic parameters

Time Point	Group	HR (beats/min)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	p-value (between groups)
Baseline	Atenolol	78 ± 7	118 ± 8	75 ± 6	90 ± 6	>0.05
	Placebo	79 ± 6	119 ± 9	76 ± 7	91 ± 7	
Post-intubation	Atenolol	82 ± 8	122 ± 10	78 ± 7	93 ± 7	<0.001
	Placebo	96 ± 10	138 ± 11	88 ± 8	105 ± 8	
5 min pneumoperitoneum	Atenolol	84 ± 9	124 ± 9	79 ± 6	95 ± 6	<0.001
	Placebo	102 ± 12	144 ± 12	91 ± 9	109 ± 9	
30 min pneumoperitoneum	Atenolol	83 ± 8	123 ± 8	78 ± 7	94 ± 6	<0.001
	Placebo	101 ± 11	142 ± 11	89 ± 8	107 ± 8	
60 min pneumoperitoneum	Atenolol	82 ± 7	122 ± 8	77 ± 6	93 ± 6	<0.001
	Placebo	100 ± 10	141 ± 10	88 ± 7	106 ± 7	

Discussion

This randomized controlled trial showed that oral atenolol given before laparoscopic cholecystectomy effectively reduced the cardiovascular responses commonly seen during intubation and pneumoperitoneum. Patients who received atenolol maintained lower heart rate and blood pressure values compared to those given placebo, and importantly, none developed significant side effects such as hypotension or bradycardia. These results highlight atenolol as a useful and safe option for maintaining perioperative stability.

Our findings are consistent with earlier clinical investigations into the role of beta-blockers in anesthesia. Several researchers, including Mikawa and Oxorn, reported that atenolol attenuates the sympathetic surge associated with laryngoscopy. Chung and colleagues also noted a protective effect against perioperative ischemia in patients at cardiac risk. By confirming these outcomes in the context of laparoscopic cholecystectomy, the present study adds to the growing body of evidence supporting atenolol's use in non-cardiac surgeries.

When compared with other pharmacological strategies, atenolol shows clear practical benefits. While opioids can reduce sympathetic responses, they frequently prolong recovery and increase the risk of respiratory depression. Vasodilators lower arterial pressure but often produce reflex tachycardia, undermining their usefulness. Alpha-2 agonists such as clonidine and dexmedetomidine offer strong sympatholytic effects but are associated with higher costs and risks of sedation, hypotension, or bradycardia. Atenolol, by contrast, is inexpensive, easy to administer orally, long-acting, and associated with a favorable safety record when used in appropriate doses.

The mechanism underlying these benefits is straightforward. Atenolol selectively blocks β1-adrenergic receptors in the heart, limiting the effect of catecholamines during surgical stimulation. This results in reduced chronotropy and inotropy, translating into lower heart rate, blood pressure, and myocardial oxygen demand. Because it spares β2 receptors, atenolol avoids many of the bronchial and vascular side effects seen with non-selective beta-blockers. Its pharmacokinetics, including a half-life of 6–9 hours, ensure adequate coverage throughout the operative period when administered orally before surgery.

Clinically, the implications are important. Laparoscopic cholecystectomy is among the most common surgical procedures worldwide, and while many patients are young and healthy, a substantial proportion have coexisting conditions such as hypertension or coronary artery disease. For these individuals, perioperative surges in blood pressure or heart rate may carry significant risk. Atenolol provides an effective means of blunting such changes, making it an attractive choice, particularly in hospitals where cost and resource availability are major considerations.

The present study had notable strengths, including its randomized and double-blind design, which reduced bias, and the systematic measurement of hemodynamic variables at key perioperative moments. However, some limitations must be acknowledged. The trial was performed at a single center and included only ASA I–II patients between 30 and 60 years, restricting applicability to elderly or higher-risk groups. Furthermore, the study did not assess long-term outcomes such as postoperative ischemia, arrhythmias, or recovery quality. These limitations suggest that while the findings are promising, they should be interpreted within the context of the study design.

Future research could address these gaps by including larger, multicenter populations with broader age ranges and comorbidities. Direct comparisons of atenolol with other commonly used agents such as esmolol, clonidine, or dexmedetomidine would also clarify relative

benefits. Additionally, evaluating cost-effectiveness and long-term outcomes would strengthen the case for routine use. If supported by further evidence, atenolol has the potential to become a standard premedication in laparoscopic surgery, combining effectiveness, safety, and affordability.

Conclusion

The findings of this randomized controlled study indicate that oral atenolol given before laparoscopic cholecystectomy provides reliable protection against the hemodynamic disturbances commonly triggered by intubation and pneumoperitoneum. Patients premedicated with atenolol maintained more stable heart rate and blood pressure values compared with those receiving placebo, and these benefits were achieved without notable complications such as hypotension, bradycardia, or arrhythmias. By selectively blocking cardiac β1 receptors, atenolol reduces sympathetic drive and myocardial oxygen demand, offering a favorable balance between efficacy and safety. Its oral formulation, predictable duration of action, affordability, and cardioselectivity make it a practical choice for day-to-day anesthetic practice, particularly in high-volume or resource-limited settings. In contrast to other drugs used to blunt stress responses, atenolol combines effectiveness with ease of use and minimal side effects. The results suggest that incorporating atenolol into preoperative protocols could enhance cardiovascular stability during laparoscopic surgery, improve patient safety, and lower the risk of adverse perioperative events. Overall, oral atenolol emerges as a simple, safe, and cost-effective premedication strategy for patients undergoing laparoscopic cholecystectomy.

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