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Original Research Article

# Dose-Dependent Effects of Dexmedetomidine on Hemodynamic Stability During Extubation in Open Cholecystectomy: A Comparative Study

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**Abstract:**

**Background:** The process of tracheal extubation is often associated with significant sympathetic stimulation, leading to undesirable hemodynamic responses including tachycardia and hypertension. These responses may be particularly harmful in patients undergoing open abdominal surgeries like cholecystectomy. Dexmedetomidine, a selective alpha-2 adrenergic agonist, has shown promise in blunting the extubation response.

**Aim:** To evaluate and compare the efficacy of different doses of dexmedetomidine in attenuating the hemodynamic and stress response during extubation in patients undergoing open cholecystectomy.

**Methods:** This comparative study was conducted over a period of one year at Sheikh Bhikari Medical College and Hospital, Hazaribagh, Jharkhand, India. Sixty adult patients undergoing elective open cholecystectomy under general anesthesia were randomly assigned into three groups of 20 each. Group A received dexmedetomidine 0.5 µg/kg, Group B received 0.75 µg/kg, and Group C received 1.0 µg/kg, each administered as an infusion over 10 minutes before extubation. Hemodynamic parameters, extubation quality, sedation levels, and adverse effects were assessed.

**Results:** All three groups showed attenuation of extubation response, but Group C demonstrated the most significant reduction in heart rate and mean arterial pressure, with smoother extubation and better sedation levels. Incidence of bradycardia and hypotension was slightly higher in Group C but manageable. Group B offered an optimal balance between efficacy and safety.

**Conclusion:** Dexmedetomidine effectively attenuates extubation response in a dose-dependent manner. A dose of 0.75 µg/kg provides an effective compromise between hemodynamic stability and minimal side effects, making it a preferable choice during extubation in open cholecystectomy.



## Introduction

The extubation phase of general anesthesia is a critical event marked by a surge in sympathetic activity triggered by airway manipulation and removal of the endotracheal tube. This stimulation frequently leads to undesirable hemodynamic responses such as tachycardia, hypertension, arrhythmias, and increased intracranial or intraocular pressure. Although transient in nature, these responses may carry significant perioperative risk, particularly in patients undergoing abdominal surgeries like open cholecystectomy, where stability of cardiovascular parameters is essential for adequate tissue perfusion and recovery. Moreover, these responses may exacerbate pain perception and increase the risk of postoperative complications such as bleeding or cardiac ischemia.

Various pharmacological strategies have been employed to blunt the extubation response, including the use of lidocaine, opioids, beta-blockers, calcium channel blockers, and alpha-2 adrenergic agonists. Among these, dexmedetomidine, a highly selective alpha-2 adrenoceptor agonist, has gained considerable attention in recent years due to its unique sedative, anxiolytic, sympatholytic, and analgesic properties with minimal respiratory depression. Dexmedetomidine reduces norepinephrine release by acting on presynaptic alpha-2 receptors in the locus coeruleus and spinal cord, thereby attenuating the cardiovascular stress response associated with extubation. In addition, it offers smooth emergence from anesthesia and has a favorable impact on postoperative analgesia and sedation quality.

Although several studies have demonstrated the effectiveness of dexmedetomidine in modulating hemodynamic responses during extubation, the optimal dosing strategy remains a matter of clinical interest. Higher doses may provide superior

attenuation of sympathetic activity but carry the risk of bradycardia, hypotension, and excessive sedation. Conversely, lower doses may be safer but less effective in achieving hemodynamic control. Therefore, determining a dose that balances efficacy and safety is critical for routine clinical application.

The open cholecystectomy procedure, although less common than its laparoscopic counterpart, is still widely performed in patients with complicated gallbladder disease or in regions with limited laparoscopic access. In such cases, adequate control of peri-extubation stress becomes essential, as hemodynamic fluctuations may adversely impact postoperative recovery and outcomes.

This study was undertaken to evaluate the dose-dependent effects of dexmedetomidine in attenuating extubation-induced hemodynamic responses in patients undergoing open cholecystectomy. By comparing three clinically relevant doses 0.5 µg/kg, 0.75 µg/kg, and 1.0 µg/kg.

This study aims to identify the optimal dose that ensures maximum hemodynamic stability with minimal adverse effects. The findings are expected to guide anesthesiologists in selecting the most appropriate dexmedetomidine dosing regimen for extubation in abdominal surgeries, enhancing safety and improving perioperative patient care.

## Material and Methods

This comparative study was conducted over a period of one year in the Department of Anesthesiology at Sheikh Bhikari Medical College and Hospital, Hazaribagh, Jharkhand, India, The study included 60 adult patients aged between 18 and 60 years, of either sex, with American Society of Anesthesiologists (ASA) physical status I or II, scheduled for elective open cholecystectomy under general anesthesia. Patients were excluded if they had known hypersensitivity to dexmedetomidine, bradyarrhythmias, significant hepatic or renal dysfunction, uncontrolled hypertension, psychiatric illness, chronic opioid, or sedative use, or anticipated difficult airway. Pregnant and lactating women were also excluded from the study.

Patients were randomly assigned into three equal groups of 20 each using a computer-generated randomization table. Group A received dexmedetomidine 0.5 µg/kg, Group B received 0.75 µg/kg, and Group C received 1.0 µg/kg. The respective dose of dexmedetomidine was diluted in 100 ml of normal saline and administered intravenously over 10 minutes, exactly 15 minutes prior to planned extubation, under strict monitoring. All patients underwent standardized general anesthesia protocols including premedication with midazolam and glycopyrrolate, induction with propofol and succinylcholine, maintenance with isoflurane in a 50:50 air–oxygen mixture, and muscle relaxation with vecuronium bromide.

Vital parameters including heart rate, systolic and diastolic blood pressure, mean arterial pressure (MAP), oxygen saturation ($SpO_2$), and respiratory rate were recorded at baseline, immediately before drug infusion, immediately before extubation, and at 1, 3, 5, and 10 minutes after extubation. Sedation level was assessed using the Ramsay Sedation Scale, and the quality of extubation was graded using a standardized 5-point Extubation Quality Score. Adverse events such as bradycardia, hypotension, hypoxia, or delayed recovery were carefully monitored and managed as per institutional protocols.

The primary outcome measure was the extent of attenuation of hemodynamic response during extubation, assessed via changes in heart rate and MAP. Secondary outcomes included extubation quality, sedation level, and incidence of adverse events. All data were entered into a pre-designed proforma. Continuous variables were expressed as mean ± standard deviation and compared using one-way ANOVA followed by post-hoc Tukey's test for intergroup comparisons. Categorical variables were expressed as frequencies and percentages and analyzed using Chi-square or Fisher's exact test as appropriate. A p-value of less than 0.05 was considered statistically significant.

## Results

A total of 60 patients undergoing elective open cholecystectomy were randomized into three groups of 20 each: Group A (dexmedetomidine 0.5 µg/kg), Group B (0.75 µg/kg), and Group C (1.0 µg/kg). The groups were compared for demographic variables, hemodynamic response during extubation, sedation scores, extubation quality, and adverse effects.

**Table 1: Demographic Profile of Patients**

| Parameter | Group A (n = 20) | Group B (n = 20) | Group C (n = 20) |
|---|---|---|---|
| Mean Age (years) | 38.7 ± 9.6 | 39.2 ± 8.4 | 37.9 ± 9.2 |
| Male | 12 (60.0%) | 13 (65.0%) | 11 (55.0%) |
| Female | 8 (40.0%) | 7 (35.0%) | 9 (45.0%) |
| ASA Grade I | 14 (70.0%) | 15 (75.0%) | 13 (65.0%) |
| ASA Grade II | 6 (30.0%) | 5 (25.0%) | 7 (35.0%) |

**Table 2: Heart Rate Variation at Different Time Points**

| Time Point | Group A | Group B | Group C |
|---|---|---|---|
| Baseline (bpm) | 84.5 ± 6.8 | 83.9 ± 7.2 | 84.7 ± 6.9 |
| Pre-extubation | 91.6 ± 8.3 | 87.2 ± 7.1 | 82.4 ± 6.5 |
| 1 min post-extubation | 98.5 ± 9.4 | 91.3 ± 7.6 | 85.2 ± 6.1 |
| 5 min post-extubation | 92.8 ± 8.1 | 88.6 ± 7.0 | 83.7 ± 6.3 |
| 10 min post-extubation | 87.2 ± 7.5 | 85.4 ± 6.8 | 81.1 ± 5.9 |

**Table 3: Mean Arterial Pressure (MAP) Trends**

| Time Point | Group A (mmHg) | Group B (mmHg) | Group C (mmHg) |
|---|---|---|---|
| Baseline | 93.4 ± 5.7 | 92.9 ± 5.3 | 93.1 ± 5.8 |
| Pre-extubation | 99.6 ± 6.8 | 96.1 ± 5.6 | 90.7 ± 4.9 |
| 1 min post-extubation | 106.3 ± 7.4 | 99.2 ± 6.2 | 93.8 ± 5.1 |
| 5 min post-extubation | 98.1 ± 6.1 | 94.7 ± 5.9 | 89.6 ± 4.7 |
| 10 min post-extubation | 95.2 ± 5.8 | 92.3 ± 5.5 | 87.4 ± 4.5 |

**Table 4: Oxygen Saturation ($SpO_2$) Trends**

| Time Point | Group A (%) | Group B (%) | Group C (%) |
|---|---|---|---|
| Baseline | 98.3 ± 0.6 | 98.2 ± 0.5 | 98.1 ± 0.5 |
| Pre-extubation | 98.1 ± 0.7 | 98.2 ± 0.6 | 98.0 ± 0.6 |
| 1 min post-extubation | 97.9 ± 0.7 | 98.0 ± 0.6 | 97.8 ± 0.5 |

**Table 5: Ramsay Sedation Score (Pre-Extubation)**

| Sedation Score | Group A | Group B | Group C |
|---|---|---|---|
| Mean RSS | 2.8 ± 0.4 | 3.4 ± 0.5 | 3.9 ± 0.4 |

**Table 6: Extubation Quality Score**

| Score Category | Group A (n) | Group B (n) | Group C (n) |
|---|---|---|---|
| Score 1 (Excellent) | 6 (30.0%) | 11 (55.0%) | 15 (75.0%) |
| Score 2 (Good) | 8 (40.0%) | 7 (35.0%) | 4 (20.0%) |
| Score 3–5 | 6 (30.0%) | 2 (10.0%) | 1 (5.0%) |

**Table 7: Incidence of Cough at Extubation**

| Cough Response | Group A | Group B | Group C |
|---|---|---|---|
| No Cough | 5 (25.0%) | 9 (45.0%) | 13 (65.0%) |
| Mild Cough | 10 (50.0%) | 9 (45.0%) | 6 (30.0%) |
| Moderate/Severe Cough | 5 (25.0%) | 2 (10.0%) | 1 (5.0%) |

**Table 8: Adverse Events Observed**

| Adverse Event | Group A (n = 20) | Group B (n = 20) | Group C (n = 20) |
|---|---|---|---|
| Bradycardia | 1 (5.0%) | 2 (10.0%) | 3 (15.0%) |
| Hypotension | 0 (0.0%) | 1 (5.0%) | 3 (15.0%) |
| Nausea | 2 (10.0%) | 2 (10.0%) | 2 (10.0%) |

**Table 9: Recovery Time (Aldrete Score ≥9)**

| Recovery Time | Group A | Group B | Group C |
|---|---|---|---|
| Mean ± SD (minutes) | 22.3 ± 3.5 | 24.6 ± 3.9 | 27.1 ± 4.2 |

**Table 10: Time to First Analgesic Requirement**

| Time to Rescue Analgesia | Group A | Group B | Group C |
|---|---|---|---|
| Mean ± SD (minutes) | 97.2 ± 12.3 | 112.4 ± 13.8 | 121.7 ± 15.1 |

**Table 11: Surgeon Satisfaction Score**

| Satisfaction Level | Group A | Group B | Group C |
|---|---|---|---|
| Excellent | 10 (50.0%) | 13 (65.0%) | 14 (70.0%) |
| Good | 8 (40.0%) | 6 (30.0%) | 5 (25.0%) |
| Fair | 2 (10.0%) | 1 (5.0%) | 1 (5.0%) |

**Table 12: Patient Satisfaction Score**

| Satisfaction Level | Group A | Group B | Group C |
|---|---|---|---|
| Excellent | 9 (45.0%) | 13 (65.0%) | 15 (75.0%) |
| Good | 8 (40.0%) | 6 (30.0%) | 4 (20.0%) |
| Fair | 3 (15.0%) | 1 (5.0%) | 1 (5.0%) |

**Table Summary:**

Table 1 confirms that all groups were demographically comparable, validating the randomization. Table 2 shows a dose-dependent reduction in heart rate during extubation, with Group C exhibiting the greatest suppression. Table 3 reflects similar MAP trends, indicating that higher doses more effectively attenuated pressor response. Table 4 confirms stable oxygen saturation levels across all groups. Table 5 indicates that pre-extubation sedation increased progressively with higher doses. Table 6 demonstrates smoother extubation quality in higher dose groups. Table 7 reveals less coughing during extubation with increasing dexmedetomidine doses. Table 8 presents a higher but manageable incidence of bradycardia and hypotension in Group C. Table 9 shows slightly longer recovery time with higher doses, though all patients recovered adequately. Table 10 highlights prolonged analgesic duration with increasing doses. Table 11 shows surgeon satisfaction improving with better intraoperative conditions at higher doses. Table 12 illustrates greater patient satisfaction in the higher dose group, supporting improved perioperative experience.

**Discussion**

The extubation phase of general anesthesia is a physiologically stressful event, commonly accompanied by a sudden increase in sympathetic nervous system activity. This manifests as acute surges in heart rate and blood pressure, which can be particularly detrimental in patients undergoing open abdominal surgeries like cholecystectomy, where intra-abdominal pressures, vascular integrity, and postoperative pain are significant considerations. Therefore, mitigating the hemodynamic response during extubation is a critical objective for anesthesiologists, especially in high-risk or unstable surgical settings.

Dexmedetomidine, a highly selective alpha-2 adrenergic agonist, has shown considerable efficacy in this regard. It provides sedation, anxiolysis, and analgesia without significant respiratory depression and has proven beneficial in various perioperative settings. By inhibiting norepinephrine release through pre- and postsynaptic alpha-2 receptors, dexmedetomidine blunts sympathetic responses and reduces cardiovascular excitability during extubation. In the present study, we evaluated the effectiveness of three different doses—0.5 µg/kg, 0.75 µg/kg, and 1.0 µg/kg—administered pre-extubation in patients undergoing open cholecystectomy.

The results of this study clearly demonstrate a dose-dependent attenuation of the extubation response. Group C, receiving the highest dose (1.0 µg/kg), exhibited the most significant suppression in both heart rate and mean arterial pressure during and after extubation. This aligns with the pharmacodynamic profile of dexmedetomidine, which at higher doses exerts stronger sympatholytic effects. Importantly, these hemodynamic changes were consistent across time intervals, suggesting stable and sustained action. However, this benefit came at the cost of a marginally increased incidence of bradycardia and hypotension, necessitating closer intraoperative monitoring.

Group B (0.75 µg/kg) demonstrated an effective balance between hemodynamic control and adverse effect profile. It provided comparable attenuation of extubation responses without the hemodynamic compromise seen in the higher dose group. This intermediate dose was also associated with smoother extubation quality, improved sedation scores, fewer episodes of coughing, and better patient comfort, making it the most clinically desirable of the three regimens.

The lowest dose, 0.5 µg/kg (Group A), was effective in reducing cardiovascular reactivity to some extent but was clearly inferior in achieving optimal suppression compared to the higher doses. Although associated with fewer adverse events, its limited ability to blunt the extubation response and lower satisfaction ratings indicate a suboptimal clinical profile for open cholecystectomy settings, where surgical trauma and visceral pain are more pronounced than in minimally invasive procedures.

One of the major advantages of dexmedetomidine over traditional agents like opioids, beta-blockers, or local anesthetics is its ability to suppress stress response while maintaining spontaneous ventilation and arousable sedation. In this study, all groups maintained adequate oxygen saturation throughout, reinforcing the safety of dexmedetomidine across the studied dosing spectrum. Additionally, sedation as assessed by the Ramsay Sedation Scale showed a direct correlation with the dose, with higher doses producing more profound sedation. This not only contributed to reduced airway reflex stimulation during extubation but also delayed the onset of postoperative discomfort and analgesic requirement, particularly in Group C.

The extended duration until the first analgesic requirement in higher dose groups is another important clinical observation. The alpha-2 agonist

properties of dexmedetomidine modulate pain transmission at both spinal and supraspinal levels, contributing to opioid-sparing effects postoperatively. This was reflected in the increased patient satisfaction scores and reduced rescue analgesic needs in Groups B and C.

Surgeon satisfaction, often overlooked in anesthetic trials, was uniformly high across all groups, with slightly better scores in the higher dose arms. This is likely attributed to smoother emergence, less coughing, and better intraoperative hemodynamic control—conditions that facilitate a more predictable and less stressful operating environment.

Despite its strengths, the study is not without limitations. The single-center design and relatively small sample size may limit the external validity of findings. Moreover, the study did not examine long-term outcomes such as delayed sedation, postoperative cognitive effects, or hospital discharge timing. Future research should include larger multicenter cohorts and explore multimodal combinations or infusion-based regimens for individualized extubation strategies.

Nevertheless, the current study adds valuable insight to the anesthetic literature by directly comparing three clinically relevant doses of dexmedetomidine in a standardized surgical context. The findings suggest that while all three doses provide benefit, 0.75 µg/kg may offer the optimal trade-off between efficacy and safety, particularly in open abdominal surgeries requiring tighter hemodynamic control during emergence.

## Conclusion

Dexmedetomidine is an effective agent for attenuating the hemodynamic response during extubation in patients undergoing open cholecystectomy. This study demonstrates a clear dose-dependent efficacy, with 1.0 µg/kg providing the greatest suppression of heart rate and blood pressure changes. However, this higher dose was also associated with a slightly increased incidence of bradycardia and hypotension. The intermediate dose of 0.75 µg/kg achieved an optimal balance between hemodynamic control, minimal adverse effects, and better extubation conditions. Based on these findings, dexmedetomidine at 0.75 µg/kg may be considered the most clinically appropriate dose for safe and effective attenuation of extubation response in open cholecystectomy patients.

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