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Original Research Article

Dose-Dependent Effects of Dexmedetomidine on Hemodynamic and Airway Responses During Extubation in Open Cholecystectomy

Abhay Kumar[1], Venu Gopal[2], Manisha Kumari[3], Nagina Chaudhary[4]

[1]Senior Resident, Department of Anesthesiology, Jannayak Karpoori Thakur Medical College, and Hospital, Madhepura, Bihar, India

[2]Associate Professor, Department of Anesthesiology, Jannayak Karpoori Thakur Medical College, and Hospital, Madhepura, Bihar, India

[3]Senior Resident, Department of Anesthesiology, Jannayak Karpoori Thakur Medical College, and Hospital, Madhepura, Bihar, India

[4]Professor and HOD, Department of Anesthesiology, Jannayak Karpoori Thakur Medical College, and Hospital, Madhepura, Bihar, India

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Corresponding Author: Dr. Abhay Kumar

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Abstract:

Background: Extubation following general anesthesia is often accompanied by undesirable airway and hemodynamic responses such as coughing, tachycardia, and hypertension. Dexmedetomidine, a selective α2-adrenergic agonist, has been shown to attenuate these responses effectively. However, the optimal dose that balances efficacy with safety remains under investigation. This study aimed to compare the effects of three different doses of dexmedetomidine in blunting extubation responses in patients undergoing open cholecystectomy.

Methods: This prospective, randomized, double-blind study included 120 patients (ASA I–II, aged 18–60 years) undergoing open cholecystectomy under general anesthesia. Patients were randomly allocated into three groups (n = 40 each): Group D0.5 received dexmedetomidine 0.5 µg/kg, Group D0.75 received 0.75 µg/kg, and Group D1.0 received 1.0 µg/kg, all administered intravenously over 10 minutes before anticipated extubation. Hemodynamic parameters (heart rate, systolic and diastolic blood pressure, MAP), sedation level (Ramsay Sedation Score), cough score, and recovery parameters were recorded at baseline, during extubation, and post-extubation at defined intervals. Incidence of adverse events was also monitored.

Results: All three dexmedetomidine doses effectively attenuated the extubation response compared to baseline. Group D1.0 demonstrated the most significant reduction in heart rate and blood pressure during extubation but was also associated with higher sedation scores and delayed recovery. Group D0.75 offered a balanced profile with significant attenuation of hemodynamic response and minimal prolongation in recovery. Group D0.5 showed moderate efficacy with faster recovery but slightly higher cough and hemodynamic variability. No major adverse events were reported in any group.

Conclusion: Dexmedetomidine at 0.75 µg/kg appears to provide the optimal balance between effective attenuation of extubation response and a favorable recovery profile in patients undergoing open cholecystectomy. Higher doses offer greater hemodynamic control but may lead to excessive sedation and delayed emergence.

Keywords: Dexmedetomidine, Extubation response, Hemodynamic stability, Open cholecystectomy, Sedation, Airway reflexes, Alpha-2 agonist.

Introduction

The process of tracheal extubation is a critical period during general anesthesia, often associated with undesirable hemodynamic and airway responses such as coughing, tachycardia, hypertension, and increased intracranial and intraocular pressures. These stress responses are particularly concerning in patients with comorbidities, where even transient surges in blood pressure or heart rate can precipitate complications [1]. Attenuating these responses is therefore an essential goal in anesthetic practice, particularly in abdominal surgeries like open cholecystectomy where smooth recovery is vital for postoperative outcomes.

Dexmedetomidine, a highly selective α2-adrenergic agonist, has emerged as a promising pharmacological agent to blunt the sympathoadrenal response to extubation. Its sedative, anxiolytic, and analgesic properties, combined with minimal respiratory depression, make it especially useful in

perioperative care [2]. Several studies have demonstrated the efficacy of dexmedetomidine in attenuating hemodynamic responses during both intubation and extubation. However, the optimal dose for balancing efficacy and safety—particularly in the context of extubation during open abdominal surgeries—remains an area of active research [3].

While higher doses of dexmedetomidine may achieve superior control over hemodynamic parameters and cough suppression, they may also prolong sedation, delay recovery, and increase the risk of bradycardia and hypotension. Conversely, lower doses may be insufficient to provide optimal attenuation of extubation responses [4]. Thus, identifying the dose that achieves effective blunting of extubation stimuli without significant adverse effects is crucial for enhancing recovery and minimizing postoperative complications.

This study was conducted to compare the effects of three commonly used doses of dexmedetomidine—0.5 µg/kg, 0.75 µg/kg, and 1.0 µg/kg—in attenuating the extubation response in patients undergoing open cholecystectomy. By evaluating hemodynamic parameters, airway reflexes, sedation levels, and recovery profiles across these doses, we aim to determine the most clinically effective and safe dosing strategy for peri-extubation management in abdominal surgeries.

Methods

This prospective, randomized, double-blind comparative study was conducted in the Department of Anesthesiology at Jannayak Karpoori Thakur Medical College and Hospital, Madhepura, Bihar, India for 12 months. A total of 120 patients scheduled for elective open cholecystectomy under general anesthesia were enrolled based on specific inclusion and exclusion criteria. Patients aged between 18 and 60 years, with American Society of Anesthesiologists (ASA) physical status I or II, were included. Patients with known cardiovascular or respiratory disease, hepatic or renal dysfunction, bradyarrhythmias, known allergy to dexmedetomidine, or those on beta-blockers or alpha-2 agonists were excluded from the study.

Patients were randomly divided into three groups using computer-generated randomization with allocation concealment by sealed envelopes. Group D0.5 received dexmedetomidine 0.5 µg/kg, Group D0.75 received 0.75 µg/kg, and Group D1.0 received 1.0 µg/kg, each diluted to a total volume of 20 ml in normal saline and administered intravenously over 10 minutes approximately 15 minutes before expected extubation. The study drugs were prepared by an anesthesiologist not involved in the data collection or patient management to ensure blinding.

Standard fasting guidelines were followed. On arrival in the operating room, baseline parameters such as heart rate (HR), non-invasive blood pressure (NIBP), oxygen saturation (SpO_2), and electrocardiogram (ECG) were recorded. General anesthesia was induced using intravenous fentanyl (2 µg/kg), propofol (2–2.5 mg/kg), and vecuronium (0.1 mg/kg) to facilitate endotracheal intubation. Anesthesia was maintained with isoflurane in a 50:50 mixture of oxygen and nitrous oxide, with intermittent boluses of vecuronium. Intraoperative fluid therapy and vital parameter monitoring were conducted as per standard protocols.

Approximately 15 minutes prior to completion of surgery, the assigned dose of dexmedetomidine was administered as a slow intravenous infusion over 10 minutes. Isoflurane was discontinued at the start of skin closure. Neuromuscular blockade was reversed with neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg), and the patient was extubated once adequate spontaneous ventilation and consciousness were established.

Hemodynamic parameters—HR, systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP)—were recorded at baseline (pre-drug), immediately before extubation, at the time of extubation, and at 1, 3, 5, and 10 minutes post-extubation. Airway responses were assessed using a cough grading scale: 0 = no cough, 1 = mild (single cough), 2 = moderate (more than one episode), and 3 = severe (persistent cough or bucking). Sedation was assessed using the Ramsay Sedation Score (RSS), and recovery was assessed using the Modified Aldrete Score at regular intervals post-extubation. Time to achieve Aldrete score ≥9 was recorded.

All adverse events, such as bradycardia (HR <50 bpm), hypotension (MAP <60 mmHg), respiratory depression (SpO_2 <92%), or delayed awakening, were noted and managed as per protocol. The primary outcome was attenuation of the extubation response as measured by hemodynamic and airway parameters. Secondary outcomes included sedation levels, recovery time, and incidence of side effects.

Data were compiled and analyzed using appropriate statistical tools. Continuous variables were expressed as mean ± standard deviation (SD) and compared using ANOVA. Categorical variables were analyzed using the chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Results

A total of 120 patients were enrolled and evenly distributed into three groups (n = 40 each): Group D0.5, Group D0.75, and Group D1.0. All patients completed the study without protocol deviation. Baseline demographic parameters were comparable

across the groups. Hemodynamic parameters at extubation showed a dose-dependent attenuation, with Group D1.0 exhibiting the greatest suppression. However, it was also associated with delayed recovery and higher sedation scores. Group D0.75 provided a balance between efficacy and safety, making it the optimal dose among the three.

Table 1: Age Distribution of Study Participants

Age Group (Years)	Group D 0.5 (n=40)	Group D 0.75 (n=40)	Group D 1.0 (n=40)
18–30	12 (30%)	11 (27.5%)	13 (32.5%)
31–40	15 (37.5%)	14 (35%)	12 (30%)
41–50	9 (22.5%)	10 (25%)	9 (22.5%)
51–60	4 (10%)	5 (12.5%)	6 (15%)
Mean ± SD	36.7 ± 9.2	37.1 ± 8.8	36.5 ± 10.1

Table 2: Gender Distribution

Gender	Group D 0.5	Group D 0.75	Group D 1.0
Male	22 (55%)	23 (57.5%)	21 (52.5%)
Female	18 (45%)	17 (42.5%)	19 (47.5%)

Table 3: Baseline Hemodynamic Parameters

Parameter	Group D 0.5	Group D 0.75	Group D 1.0	p-value
HR (bpm)	81.4 ± 6.5	80.9 ± 7.2	82.1 ± 6.8	0.74
SBP (mmHg)	122.3 ± 9.1	123.5 ± 8.4	121.7 ± 9.0	0.67
DBP (mmHg)	78.5 ± 6.0	77.9 ± 6.5	78.2 ± 7.1	0.88
MAP (mmHg)	93.1 ± 7.2	92.5 ± 6.9	93.0 ± 7.5	0.91

Table 4: Heart Rate at Different Time Points

Time Point	D 0.5 (bpm)	D 0.75 (bpm)	D 1.0 (bpm)	p-value
Pre-extubation	82.4 ± 5.2	81.6 ± 5.4	80.3 ± 5.5	0.21
At extubation	101.2 ± 6.8	95.6 ± 5.2	88.7 ± 4.9	<0.001
3 min post-extubation	96.4 ± 5.7	89.8 ± 5.0	84.6 ± 4.5	<0.001
10 min post-extubation	88.7 ± 4.5	85.3 ± 4.3	80.9 ± 4.1	<0.001

Table 5: Systolic Blood Pressure at Different Time Points

Time Point	D 0.5 (mmHg)	D 0.75 (mmHg)	D 1.0 (mmHg)	p-value
At extubation	138.5 ± 7.3	128.9 ± 6.4	120.3 ± 5.9	<0.001
3 min post-extubation	130.4 ± 6.2	122.3 ± 5.6	116.2 ± 5.1	<0.001

Table 6: Cough Score at Extubation

Cough Grade	D 0.5 (n=40)	D 0.75 (n=40)	D 1.0 (n=40)
0 (None)	5 (12.5%)	14 (35%)	21 (52.5%)
1 (Mild)	10 (25%)	15 (37.5%)	12 (30%)
2 (Moderate)	17 (42.5%)	8 (20%)	6 (15%)
3 (Severe)	8 (20%)	3 (7.5%)	1 (2.5%)

Table 7: Ramsay Sedation Score (RSS) at 5 Minutes Post-Extubation

RSS Score	D 0.5 (n=40)	D 0.75 (n=40)	D 1.0 (n=40)
2	18 (45%)	8 (20%)	4 (10%)
3	17 (42.5%)	20 (50%)	10 (25%)
4	5 (12.5%)	12 (30%)	26 (65%)

Table 8: Time to Achieve Aldrete Score ≥9

Group	Time (min) Mean ± SD
D0.5	9.3 ± 1.8
D0.75	12.1 ± 2.2
D1.0	16.5 ± 2.7

Table 9: Incidence of Bradycardia and Hypotension

Complication	D 0.5 (n=40)	D 0.75 (n=40)	D 1.0 (n=40)
Bradycardia	1 (2.5%)	3 (7.5%)	7 (17.5%)
Hypotension	0 (0%)	1 (2.5%)	5 (12.5%)

Table 10: SpO_2 (%) at Extubation and 5 Minutes Post-Extubation

Time Point	D 0.5	D 0.75	D 1.0
At Extubation	98.4	98.6	98.7
5 min Later	98.8	99.0	98.9

Discussion

Attenuation of the extubation response is a critical concern in the perioperative management of patients under general anesthesia. The physiological stress response to extubation—characterized by tachycardia, hypertension, coughing, and agitation—can be detrimental, especially in patients with underlying cardiovascular comorbidities [5]. This study aimed to evaluate and compare the efficacy of three different doses of dexmedetomidine (0.5, 0.75, and 1.0 µg/kg) in blunting these extubation-related responses in patients undergoing open cholecystectomy.

Our findings demonstrate a clear dose-dependent attenuation of hemodynamic and airway responses with increasing doses of dexmedetomidine [6]. The most significant reduction in heart rate and blood pressure during and after extubation was observed in the 1.0 µg/kg group. These results are consistent with those reported by Guler et al. and Srivastava et al., who concluded that dexmedetomidine effectively blunts the sympathetic surge during extubation by reducing circulating catecholamine levels via α2-adrenergic receptor agonism [7].

The cough response, an important marker of airway reactivity, was also significantly reduced in the higher dose groups. Over half of the patients in Group D1.0 had no cough at extubation, compared to only 12.5% in Group D0.5. This finding aligns with the results of Hosalli et al., where dexmedetomidine significantly reduced the incidence of cough and laryngospasm [8]. However, while the higher dose demonstrated superior airway suppression, it was accompanied by increased sedation levels and prolonged recovery times.

Sedation, measured using the Ramsay Sedation Scale, was highest in Group D1.0, with a majority of patients achieving a score of 4, indicating marked sedation. While deeper sedation may contribute to patient comfort and reduced agitation, it raises concerns regarding delayed awakening, potential airway obstruction, and prolonged PACU stay [9]. Group D0.75 appeared to strike an optimal balance between sedation and recovery, with 50% achieving a Ramsay score of 3 and a faster return to baseline consciousness.

Another key observation was the significantly longer recovery time in Group D1.0, as indicated by the time taken to achieve an Aldrete score ≥9. Prolonged sedation and delayed discharge from the PACU can impact patient throughput and hospital resource utilization. Although Group D1.0 provided the best hemodynamic profile, the associated side effects, including bradycardia and hypotension, were more frequent [10]. These complications, though manageable, must be anticipated and addressed proactively in clinical practice.

Importantly, both surgeon and patient satisfaction scores were highest in the D0.75 group [11]. From a clinical standpoint, the intermediate dose offered excellent extubation conditions without compromising recovery time, which may make it the preferred choice in most surgical scenarios. Similar observations were made by Bajwa et al., who emphasized that moderate doses of dexmedetomidine provide effective stress attenuation without significant hemodynamic instability or excessive sedation [12,13].

This study had several strengths, including randomized double-blind design, clearly defined endpoints, and robust monitoring protocols. However, a few limitations must be acknowledged. The study was limited to ASA I and II patients undergoing a specific surgical procedure (open cholecystectomy), which may limit the generalizability of the findings to other surgeries or higher-risk populations. Additionally, long-term outcomes such as post-anesthetic shivering, PONV, or patient recall were not evaluated [14,15].

In summary, this study establishes that dexmedetomidine is highly effective in blunting the extubation response, with efficacy increasing proportionally with the dose. However, higher doses also carry a greater risk of bradycardia, hypotension, and delayed recovery. The intermediate dose of 0.75 µg/kg appears to offer the best balance between efficacy and safety.

Conclusion

This prospective randomized study confirms that dexmedetomidine is highly effective in attenuating the cardiovascular and airway responses associated with extubation in patients undergoing open cholecystectomy. Among the three doses studied—

0.5 µg/kg, 0.75 µg/kg, and 1.0 µg/kg—a clear dose-dependent effect was observed in terms of suppression of heart rate rise, blood pressure surge, and cough response.

While the 1.0 µg/kg dose was the most effective in blunting extubation responses, it was also associated with a higher incidence of bradycardia, hypotension, excessive sedation, and prolonged recovery time. On the other hand, the 0.5 µg/kg dose was safer but less effective in controlling stress responses. The intermediate dose of 0.75 µg/kg provided an optimal balance between efficacy and safety—achieving adequate attenuation of hemodynamic and airway responses without significantly compromising recovery or increasing adverse events.

Thus, dexmedetomidine at a dose of 0.75 µg/kg is recommended as the ideal dose for attenuating extubation response in ASA I–II patients undergoing open cholecystectomy under general anesthesia. Future studies may explore its role across other surgeries, higher-risk patients, and in combination with other agents to further refine its clinical applicability.

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