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Research Article

Effect of Dexmedetomidine on Hemodynamic and Recovery Responses during Tracheal Extubation

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ABSTRACT

Background: Extubation, the transition from controlled anesthesia to spontaneous breathing, is a critical perioperative phase associated with risks such as laryngospasm, bronchospasm, hemodynamic instability, desaturation, and arrhythmias. Smooth extubation, defined as the absence of coughing, straining, or airway obstruction, is vital for patient safety. Dexmedetomidine, a selective α2-adrenergic agonist with sedative, analgesic, and sympatholytic properties, provides stable conditions without respiratory depression, making it a promising agent for extubation. This study aimed to assess the impact of dexmedetomidine on hemodynamic stability and recovery responses during tracheal extubation. Objectives included evaluating the quality of extubation, the level of postoperative sedation, and drug-related adverse effects.

Methods: In this prospective, double-blind, randomized trial, 60 ASA I/II adult patients undergoing elective surgery under general anesthesia were allocated into two groups (n=30 each). Group D received dexmedetomidine 0.5 mcg/kg in 100 ml saline over 15 minutes, and Group N received 100 ml saline before extubation. Heart rate, blood pressure, mean arterial pressure, and saturation were recorded perioperatively. Extubation was assessed using the Extubation Quality Score (EQS), sedation with the Ramsay Sedation Score (RSS), and adverse events were documented.

Results: Both groups were demographically comparable. Group D had significantly lower hemodynamic responses, higher sedation (RSS 2.08 vs. 1.02; p<0.0001), and smoother extubation (EQS 1.18 vs. 1.84; p=0.0012). Bradycardia and sedation were more frequent in Group D, while nausea and vomiting occurred only in Group N.

Conclusion: Dexmedetomidine 0.5 mcg/kg before extubation improved hemodynamic stability, sedation, and extubation quality, though careful monitoring is required for bradycardia and hypotension.

Introduction

Extubation is an essential phase during the perioperative period, being the process of transition from controlled anesthesia to spontaneous ventilation and recovery. Despite its clinical significance, extubation tends to attract less attention than intubation, even though it poses a similar risk of airway-related complications. Most serious events, such as laryngospasm, bronchospasm, and desaturation, usually happen during emergence and the very early postoperative period. Hence, an extubation plan that is well managed is paramount to secure patient safety and the best possible results [1-2].

Smooth extubation is defined as one where there is no coughing, straining, breath-holding, or airway obstruction. Nevertheless, the physiological stress response to extubation can cause transient hypertension, tachycardia, arrhythmias, and increased intracranial or intraocular pressure, each of which tends to impair

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recovery, particularly in at-risk patients. Extubation failure necessitating re-intubation is also related to increased morbidity, longer hospital stays, higher complication rates, and greater healthcare costs [3-4].

Several pharmacological agents, including lidocaine, opioids, esmolol, calcium channel blockers, magnesium sulphate and propofol, have been employed to suppress these emergence responses. Their efficacy is mostly compromised due to unfavorable side effects such as respiratory depression or hemodynamic instability [5].

Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, has been recognized because it can induce sedation, analgesia, and anxiolysis without respiratory depression [6]. It decreases sympathetic outflow, creating a smoother anesthetic emergence, thereby preserving cardiovascular stability. It has also been linked with decreased postoperative nausea and vomiting, improved quality of sleep, less shivering, and better overall patient comfort. All these advantages make it an intriguing agent in the quest for safer, more comfortable extubation practices [7-8].

By these determinations, the research aimed at establishing whether dexmedetomidine would improve patient outcomes and safety during and after extubation.

Aim and Objectives

The aim of this research was to assess the impact of dexmedetomidine on hemodynamic variables and recovery responses on tracheal extubation. The objectives were to assess the extubation quality, assess postoperative sedation level, and determine drug-related side effects.

Methods

Sample size calculation

As per Bindu et al. [9], the mean systolic blood pressure of the case and control groups was found to be 106.12 ± 11.7 mmHg and 118.64 ± 11.8 mmHg, respectively. Considering the detectable difference as 13.52 mmHg, 95% CI, and the power of 80%, the estimated sample size came out to be 48 patients in total, with 24 patients for each group. To enhance the study's validity, the sample size was increased from 48 patients to 60 and allocated to 30 patients per group. The sample size was calculated using Winpepi software version 11.65.

Patient selection

This prospective, double-blind, randomized controlled trial was performed in the Department of Anesthesiology, Dr. D. Y. Patil Medical College, Hospital and Research Centre, Pimpri, Pune, over a period of one year. After Institutional Ethics Committee approval (IESC/FP/04/2025) and CTRI registration (CTRI/2025/04/084817), the trial was done in those patients undergoing elective surgery under general anesthesia (GA). All the patients underwent pre-anesthetic assessment involving appropriate laboratory tests and were enrolled only after taking informed written consent.

A total of 60 patients between the ages of 18 and 65 years, classified as ASA I or II and hemodynamically stable, were enrolled and randomly assigned into two groups of 30 each using a computer-generated randomization technique. Group D was administered 0.5 mcg/kg dexmedetomidine diluted in 100 ml normal saline intravenously over a period of 15 minutes. Group N was administered 100 ml of normal saline alone, infused over the course of 15 minutes. These interventions were administered 15 minutes before tracheal extubation. To preserve blinding, the study medications were prepared and administered by an independent anesthesiologist who did not participate in subsequent patient care or data gathering, so that the patients and outcome assessors never learned the group assignments during the study.

Patients with a known hypersensitivity to study medication, those receiving drugs that affect heart rate and blood pressure, those with severe systemic disease, neurological and psychiatric conditions, or airway difficulties, pregnant or lactating females, and those undergoing emergency procedures were excluded from the study.

Plan of anesthesia

On the day of the surgery, patients were kept nil per os for six hours and were shifted to the operating theater. Monitoring involved pulse oximetry, ECG, and measurement of noninvasive blood pressure. Anesthesia induction and maintenance in both groups were similar. Patients were premedicated with glycopyrrolate 0.2 mg IV, midazolam 1 mg IV, and fentanyl 2 µg/kg IV. Induction was done with propofol 1.5–2.5 mg/kg IV, and intubation was facilitated by muscle relaxation with vecuronium 0.1 mg/kg IV. The patient was intubated with an appropriately sized endotracheal tube, and the tube position was confirmed with auscultation and capnography. Anesthesia maintenance was provided with a combination of air and oxygen with inhalational agents like sevoflurane (1–2%) and vecuronium as needed to ensure proper depth of anesthesia. In all patients, to avoid postoperative nausea and vomiting, ondansetron 4 mg IV was given 30 minutes before completion. The study drugs were administered about 15 minutes before extubation.

Hemodynamic parameters—heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and oxygen saturation (SpO_2)—were measured at baseline (before drug administration) and at 5, 10, and 15 minutes after drug administration.

Tracheal extubation was done after surgery completion once sufficient respiratory effort and consciousness were

regained. The same hemodynamic parameters were monitored at extubation and at 5-minute intervals for 30 minutes in the postoperative period. Quality of extubation was evaluated based on cough immediately after extubation using a 5-point rating score (Extubation Quality Score):

1= No coughing
2= Smooth extubation, minimal coughing (1 or 2 times)
3= Moderate coughing (3 or 4 times)
4= Severe coughing (5-10 times), straining
5= Poor extubation, very uncomfortable (laryngospasm and coughing >10 times).

Postoperative sedation was evaluated on a 6-point score (Ramsay Score):

1= Anxious or agitated and restless or both
2= Cooperative, oriented, and tranquil
3= Drowsy but responds to commands
4= Asleep, brisk response to light glabellar tap or loud auditory stimulus
5= Asleep, sluggish response to light glabellar tap or loud auditory stimulus
6= Asleep and unarousable.

Any untoward event of bradycardia, hypotension, respiratory depression, nausea or vomiting, laryngospasm, bronchospasm, or excessive sedation was noted carefully [10-11].

Bradycardia was considered a heart rate of less than 60 beats per minute, and hypotension was systolic blood pressure less than 60 mm Hg and/or mean arterial pressure (MAP) less than 60 mm Hg. These were treated with atropine 0.6 mg IV and mephentermine 6 mg IV, respectively.

For statistical analysis, all the data were pooled and analyzed using SPSS v.27.0. Quantitative variables were presented as mean ± standard deviation and compared between groups using unpaired t-tests. Categorical variables were compared using the chi-square test. A P value < 0.05 was considered to be statistically significant.

Results

60 patients were randomized into 2 groups (Figure 1).

The two groups were similar regarding demographic parameters, with no statistically significant differences being observed between gender, age, ASA status, weight, and height of the patients, and duration of surgery. These are depicted in (Table 1).

The hemodynamic parameters HR, SBP, DBP, MAP, and SpO_2 were comparable between Group D and Group N before the drug was administered. During and after administration of the study drug and during pre-extubation, the above values were lower in Group D than in Group N, but were not of statistical significance. At extubation, there was a significant alteration. HR, SBP, DBP, and MAP increased significantly in both groups, likely a response to the physiological stress of extubation. The rise was significantly more attenuated in Group D than in Group N, suggesting improved hemodynamic control.

This substantial intergroup variation continued during the period immediately after extubation, with Group D having significantly lower HR, SBP, DBP, and MAP values up to 20 minutes following extubation. These results indicate that the intervention in Group D was successful in blunting the hemodynamic response to extubation and early postoperative recovery.

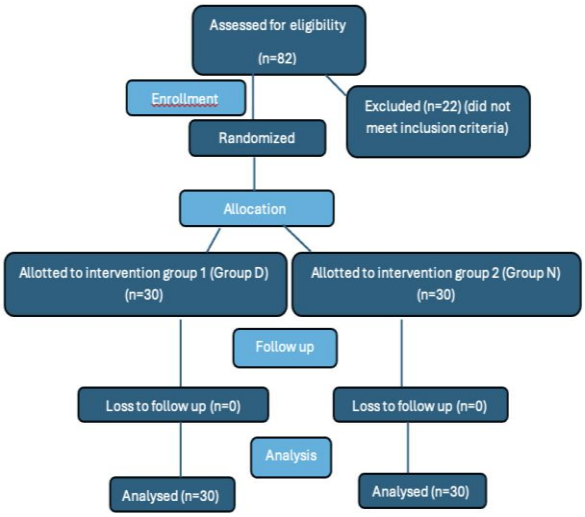

Figure 1- CONSORT flow diagram

Table 1- Demographic parameters and duration of surgery

	Group D	Group N	P value
Gender (M/F)	18/12	17/13	0.754
Age (years)	37.5±7.2	39.7±6.4	0.216
ASA I/II	14/16	13/17	0.843
Weight (kg)	74.7±7.8	72.5±8.4	0.2975
Height (cm)	177.3±12.5	179.8±17.7	0.5299
Duration of Surgery (min)	134.7±19.6	137.9±18.5	0.5181

After 25 minutes from the time of extubation, while the hemodynamic values in Group D remained less than those in Group N, these differences were no longer significant. This can be taken as evidence for progressive normalization of hemodynamic parameters in both groups. During the entire period of observation, SpO_2 was within normal range (99–100%) in both groups and had no intergroup differences at any point in time. This data attests that there was proper oxygenation always maintained, irrespective of the intervention. The comparison of hemodynamic parameters is depicted in (Table 2,3).

Table 2- Comparison of HR, SBP, DBP, and MAP

	HR			SBP			DBP			MAP		
	Group D	Group N	P value	Group D	Group N	P value	Group D	Group N	P value	Group D	Group N	P value
Before drug administration	78.4 ± 6.3	80.1 ± 6.9	0.31	122.8 ± 9.4	124.7 ± 10.2	0.29	76.2 ± 5.7	77.5 ± 6.5	0.34	90.3 ± 6.6	91.6 ± 7.2	0.33
5 mins after drug administration	77.6 ± 5.9	80.3 ± 6.5	0.27	121.3 ± 9.1	123.9 ± 9.7	0.26	75.5 ± 5.5	77.9 ± 6.3	0.28	89.5 ± 6.4	91.4 ± 6.9	0.29
10 mins after drug administration	76.9 ± 5.6	80.6 ± 6.2	0.12	119.4 ± 8.9	123.8 ± 9.5	0.11	74.6 ± 5.4	78.4 ± 6.2	0.12	88.4 ± 6.3	91.9 ± 6.7	0.12
15 mins after drug administration	75.8 ± 5.4	80.9 ± 6.1	0.09	118.3 ± 9.0	123.7 ± 9.3	0.08	73.8 ± 5.1	78.2 ± 6.1	0.09	87.6 ± 6.0	91.7 ± 6.5	0.09
At extubation	85.9 ± 6.3	94.6 ± 6.8	0.003	136.2 ± 9.1	146.5 ± 9.8	0.001	86.7 ± 6.4	95.3 ± 7.1	0.002	103.1 ± 6.7	112.4 ± 7.3	0.001
5 mins postoperative	81.5 ± 5.9	91.2 ± 6.5	0.004	130.7 ± 8.7	140.4 ± 9.4	0.002	82.3 ± 5.8	91.0 ± 6.7	0.003	98.7 ± 6.1	107.5 ± 6.9	0.002
10 mins postoperative	78.2 ± 5.5	88.5 ± 6.1	0.007	126.8 ± 8.5	136.3 ± 9.2	0.005	79.1 ± 5.6	88.4 ± 6.5	0.006	95.3 ± 5.9	104.2 ± 6.6	0.005
15 mins postoperative	75.3 ± 5.1	85.4 ± 5.9	0.008	122.9 ± 8.3	132.8 ± 8.7	0.004	76.1 ± 5.2	85.2 ± 6.3	0.005	92.4 ± 5.7	101.5 ± 6.4	0.004
20 mins postoperative	73.8 ± 4.9	83.7 ± 5.6	0.011	120.1 ± 7.8	129.2 ± 8.5	0.009	74.2 ± 4.9	83.6 ± 6.1	0.01	90.2 ± 5.4	99.3 ± 6.1	0.009
25 mins postoperative	72.4 ± 4.6	80.2 ± 5.5	0.08	118.2 ± 7.5	125.7 ± 8.3	0.07	73.0 ± 4.7	80.5 ± 5.9	0.06	88.5 ± 5.2	95.4 ± 6.0	0.07
30 mins postoperative	71.6 ± 4.4	78.5 ± 5.3	0.14	116.4 ± 7.2	122.6 ± 8.1	0.13	71.8 ± 4.5	78.1 ± 5.7	0.12	87.0 ± 5.0	93.1 ± 5.8	0.13

Table 3- Comparison of SpO_2

	SpO_2		
	Group D	Group N	P value
Before drug administration	99.5 ± 0.3	99.6 ± 0.3	0.72
5 mins after drug administration	99.5 ± 0.4	99.6 ± 0.3	0.7
10 mins after drug administration	99.4 ± 0.3	99.6 ± 0.3	0.67
15 mins after drug administration	99.3 ± 0.3	99.5 ± 0.3	0.59
At extubation	99.5 ± 0.3	99.6 ± 0.3	0.78
5 mins postoperative	99.5 ± 0.3	99.6 ± 0.3	0.74
10 mins postoperative	99.5 ± 0.3	99.6 ± 0.2	0.65
15 mins postoperative	99.4 ± 0.3	99.5 ± 0.2	0.64
20 mins postoperative	99.4 ± 0.3	99.5 ± 0.3	0.77
25 mins postoperative	99.6 ± 0.2	99.6 ± 0.2	0.88
30 mins postoperative	99.6 ± 0.2	99.7 ± 0.2	0.85

RSS at 1 minute post-extubation showed a remarkable difference between Group D and Group N. Most patients (26 out of 30) in Group D had a sedation score of 2 (cooperative, oriented, and tranquil), and some scored 1 (anxious or agitated and restless or both) or 3 (drowsy but responds to commands). In Group N, nearly all the patients (29 out of 30) had a score of 1. No score greater than 3 was recorded by any member of each group. Statistically significant ($p < 0.0001$) was the difference between the mean RSS calculated for Group D (2.08 ± 0.28) and that of Group N (1.02 ± 0.05). These results indicate that Group D patients were more cooperative, oriented, and tranquil in the initial postoperative phase than Group N patients. The comparison of RSS is depicted in (Table 4). The evaluation of EQS at 1 minute postoperatively

demonstrated a clear and statistically significant difference between Group D and Group N. In Group D, most patients (25 out of 30) had an EQS of 1 (no coughing), with the remaining few scoring 2 (smooth extubation, minimal coughing-1 or 2 times).

Table 4- Comparison of RSS

RSS Score	Group D	Group N
1	2	29
2	26	1
3	2	0
4	0	0
5	0	0
6	0	0
Mean ± SD	2.08 ± 0.28	1.02 ± 0.05
P value	<0.0001	

None of the patients in this group scored higher than 2. Conversely, in Group N, EQS values were more widely distributed, with only 3 patients scoring 1. Most patients (22 out of 30) had a score of 2, and a small number reached a score of 3 (moderate coughing- 3 or 4 times). The mean EQS was significantly lower in Group D (1.18 ± 0.10) compared to Group N (1.84 ± 0.22), with the difference reaching strong statistical significance ($p = 0.0012$).

These results indicate that patients in Group D experienced a significantly better quality of extubation following anesthesia, likely attributable to the pharmacological intervention specific to that group. The comparison of EQS is depicted in (Table 5).

Table 5- Comparison of EQS

EQS Score	Group D	Group N
1	25	3
2	5	22
3	0	5
4	0	0
5	0	0
Mean ± SD	1.18 ± 0.10	1.84 ± 0.22
P value	0.0012	

Adverse event analysis showed significant differences between the groups. Bradycardia was found in 7 patients in Group D and not at all in the patients in Group N, a statistically significant result ($p = 0.012$). Hypotension also occurred more often in Group D, in 6 patients compared to 1 in Group N ($p = 0.004$), showing a significant difference. Nausea and vomiting were noted in only Group N (3 patients) and not in Group D; the difference was not statistically significant ($p = 0.079$). Respiratory depression did not occur in either group ($p = 1$).

Laryngospasm and bronchospasm were both seen in only Group N (2 and 1 patients, respectively), and no occurrence was seen in Group D; neither was statistically significant ($p = 0.211$ and $p = 0.427$, respectively). Excessive sedation was seen in 1 patient in Group D and none in Group N ($p = 0.678$), and it was not significant. These findings indicate that although dexmedetomidine was linked to increased bradycardia and hypotension, other side effects were limited and similar between groups. The incidence of adverse effects is depicted in (Table 6).

Table 6- Adverse effects

	Group D	Group N	P value
Bradycardia	7	0	0.012
Hypotension	6	1	0.004
Nausea and Vomiting	0	3	0.079
Respiratory Depression	0	0	1
Laryngospasm	0	2	0.211
Bronchospasm	0	1	0.427
Undue Sedation	1	0	0.678

Discussion

Tracheal extubation is often accompanied by unwanted hemodynamic and airway reactions like hypertension, tachycardia, coughing, and agitation. Several pharmacologic approaches have been tried to blunt these reactions, of which dexmedetomidine, a selective alpha-2 adrenergic agonist, has emerged because it possesses sedative, analgesic, and sympatholytic effects. The present study was conducted to analyze the effectiveness of intravenous dexmedetomidine in ensuring hemodynamic stability and a tolerable extubation profile with monitoring for adverse effects [12–14].

Demographic Parameters

The demographic parameters like age, gender distribution, ASA physical status, and operation time were statistically equivalent between the two groups. This equality of baseline parameters guarantees that the outcomes so measured are a consequence of the drug intervention and not due to demographic differences. The same baseline comparability has also been observed in research by Antony et al., Bindu et al., and Luthra et al., which makes comparative interpretations more robust [9,15-16].

Hemodynamic Parameters

The group that received dexmedetomidine exhibited a marked decrease in heart rate and mean arterial pressure during and after extubation, demonstrating its effectiveness in inhibiting sympathetic outflow. This regulated hemodynamic pattern can be specifically advantageous in patients with cardiovascular comorbidities. Our results are consistent with research conducted by Antony et al. and Bindu et al., who also exhibited striking decreases in HR and MAP after the

administration of dexmedetomidine [9,15]. Luthra et al. also verified that low (0.2 µg/kg/h) and moderate (0.4 µg/kg/h) dexmedetomidine infusions caused decreased HR and MAP during extubation [16]. Suresh et al. and Rajasekhar et al. did not observe any significant variation in HR, but MAP was decreased in the dexmedetomidine group, which indicates that modulation of HR can be dose-dependent or depend on the infusion timing [17-18].

Sedation

Sedation was accomplished in the dexmedetomidine group, with an increased Ramsay Sedation Score being noted after extubation. Notably, a single patient showed undue sedation, not requiring clinical intervention, which suggests the safety of the dose of dexmedetomidine selected. This degree of sedation made way for a smooth emergence without undue delay. These results are similar to the findings of Antony et al. and Bindu et al., who noted much higher Ramsay Sedation Scores among patients on dexmedetomidine [9,15]. Contrary to this, Suresh et al. and Rajasekhar et al. have noted similar sedation scores between the groups, most probably because of varying assessment time points or interpatient variability [17-18].

Extubation Quality

Quality of extubation was significantly better in the dexmedetomidine group, with fewer patients showing cough, straining, or movement during extubation. This is also evidenced by lower Extubation Quality Scores, suggesting an easier and safer process of extubation. Our results corroborate those of Antony et al., Bindu et al., and Reddy et al., who showed that dexmedetomidine allows smooth extubation with decreased airway reactivity [9,15,19]. Pradhan et al. also noted improved extubation conditions and decreased incidence of cough with dexmedetomidine [20].

Adverse Effects

The group with dexmedetomidine had a greater incidence of bradycardia and hypotension, both statistically significant, well-documented pharmacological effects of the drug. These side effects were treated immediately with atropine 0.6 mg IV and mephentermine 6 mg IV, respectively, and did not progress to severe complications. Our findings are corroborated by Antony et al. and Bindu et al., who also found increased incidences of bradycardia and hypotension in the dexmedetomidine group [9,15].

In concurrence with our observation, Luthra et al. and Reddy et al. also did not find any significant respiratory compromise with dexmedetomidine [16,19]. Laryngospasm and bronchospasm were observed only in the control group, not statistically significant, which indicates that perhaps dexmedetomidine prevents airway instability, as indicated also by Pradhan et al. and Luthra et al [16,20]. This study is not without limitations. All surgeries performed under general anesthesia, without limiting to one type of surgery, are included. As the surgical stimulus differs between surgeries, there could have been some discrepancies in the magnitude of the emergence response, too.

Conclusion

Pre-extubation administration of dexmedetomidine 0.5 mcg/kg markedly enhanced hemodynamic stability, extubation quality, and postoperative sedation without serious complications. Although bradycardia and hypotension were more prevalent, they could be controlled conservatively. Dexmedetomidine is an effective agent for smooth and safer extubation when coupled with proper monitoring. Its application can be especially advantageous in cardiovascular stress-risk patients during emergence.

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