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A Comparative Evaluation of Pre-operative Nebulization with Dexmedetomidine, Ketamine, and Magnesium Sulphate on Post-operative Sore Throat in Patients Undergoing Laparoscopic Surgery under General Anaesthesia.

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ABSTRACT

Background:

Following general anaesthesia with endotracheal intubation, postoperative sore throat (POST) occurs commonly and causes significant discomfort, though it is usually considered a minor complication. Its incidence ranges from 14% to over 50% and is influenced by airway manipulation, endotracheal tube characteristics, cuff pressure, duration of intubation, and inflammatory responses of the airway mucosa.Several medication strategies have been studied to minimize the rate and extent of postoperative sore throat such as topical and systemic agents with anti-inflammatory, analgesic, and membrane-stabilizing properties.

Aim:

This study aimed to compare how preoperative nebulized dexmedetomidine, ketamine, and magnesium sulphate influence the occurrence and intensity of postoperative sore throat, cough, and altered voice in laparoscopic surgical patients under general anesthesia.

Materials and Methods:

This prospective, randomized study included 90 adult patients of ASA physical status I–II undergoing elective laparoscopic surgery under general anaesthesia with endotracheal intubation. Patients were randomized into three groups (n = 30 each): Group A received nebulized dexmedetomidine 50 µg, Group B received nebulized magnesium sulphate 250 mg, and Group C received nebulized ketamine 50 mg, each diluted in 5 ml normal saline. Hemodynamic parameters, respiratory variables, oxygen saturation, and postoperative airway-related complications were assessed at predetermined intervals up to 24 hours post-extubation. Postoperative sore throat, cough, and hoarseness were graded using standardized four-point scales.

Results:

Nebulized magnesium sulphate significantly reduced the incidence and severity of postoperative sore throat, cough, and hoarseness of voice at 1, 4, 6, and 24 hours post-extubation compared to dexmedetomidine and ketamine ($p < 0.05$). Hemodynamic and respiratory parameters remained stable and comparable among all groups throughout the perioperative period.

Conclusion:

Compared with dexmedetomidine, magnesium sulphate delivered through preoperative nebulization exhibited better efficacyand ketamine in attenuating postoperative airway complications without causing adverse hemodynamic or respiratory effects.

KEYWORDS: Postoperative sore throat, nebulization, dexmedetomidine, ketamine, magnesium sulphate, general anaesthesia.

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INTRODUCTION

Although sometimes overlooked, postoperative sore throat is a common adverse outcome associated with endotracheal intubation during general anaesthesia. Although not life-threatening, it significantly affects patient comfort, satisfaction, and overall quality of recovery in the immediate postoperative period [1]. The reported incidence of POST varies widely, ranging

from 14% to as high as 50–70%, depending on patient characteristics, anaesthetic technique, and perioperative airway management practices [2,3].

The etiology of POST is multifactorial. Mechanical trauma to the pharyngeal and tracheal mucosa during laryngoscopy and intubation, pressure-induced ischemia from endotracheal tube cuffs, mucosal inflammation, and dryness caused by inhalational anaesthetic gases are considered major contributing factors [4,5]. Additional risk factors include female sex, younger age, prolonged duration of surgery, use of larger endotracheal tubes, repeated intubation attempts, high cuff pressures, and the presence of blood on the tube at extubation [6–8].

Despite advances in airway devices and anaesthetic techniques, POST continues to remain a persistent problem in modern anaesthesia practice [9]. Laparoscopic surgeries, in particular, may further exacerbate airway irritation due to pneumoperitoneum-induced physiological changes, prolonged surgical duration, and the frequent need for steep patient positioning [10].

Several non-pharmacological strategies have been proposed to reduce the incidence of POST, including careful airway manipulation, use of smaller-sized endotracheal tubes, monitoring of cuff pressure, and the use of supraglottic airway devices where appropriate [11–13]. However, these measures alone have not been entirely successful in eliminating POST, leading to increased interest in pharmacological prophylaxis.

Various topical and systemic pharmacological agents have been investigated for the prevention of POST. These include corticosteroids, lidocaine, non-steroidal anti-inflammatory drugs (NSAIDs), ketamine, magnesium sulphate, benzydamine hydrochloride, and α-2 adrenergic agonists [14–17]. Among these, nebulized and topical agents have gained popularity due to their ease of administration, rapid onset of action, and minimal systemic side effects [18].

Dexmedetomidine, a highly selective α-2 adrenergic receptor agonist, possesses sedative, analgesic, anti-inflammatory, and sympatholytic properties [19]. When administered via nebulization, dexmedetomidine exerts local anti-inflammatory effects on airway mucosa while minimizing systemic adverse effects such as hypotension and bradycardia [20]. Several studies have demonstrated its efficacy in reducing POST and attenuating airway reflexes [21].

Ketamine, an N-methyl-D-aspartate (NMDA) receptor antagonist, is well known for its analgesic and anti-hyperalgesic properties. Its topical and nebulized use has been shown to reduce airway inflammation and nociceptive transmission, thereby decreasing the incidence of POST [22,23]. Additionally, ketamine preserves airway reflexes and respiratory drive, making it an attractive option in perioperative airway management [24].

Magnesium sulphate has emerged as a promising agent for the prevention of POST due to its NMDA receptor antagonism, calcium channel blockade, and anti-inflammatory effects [25]. Nebulized magnesium sulphate acts locally on the airway mucosa, reducing inflammation, smooth muscle spasm, and nociceptive signaling [26]. Several randomized controlled trials have reported a significant reduction in POST with nebulized magnesium sulphate compared to placebo and other agents [27,28].

Despite the availability of multiple pharmacological options, there remains no universal consensus on the most effective agent for the prevention of POST. Comparative studies directly evaluating dexmedetomidine, ketamine, and magnesium sulphate via nebulization are limited, particularly in the context of laparoscopic surgeries under general anaesthesia [29].

Therefore, the present study was designed to comparatively evaluate the efficacy of pre-operative nebulization with dexmedetomidine, ketamine, and magnesium sulphate in reducing the incidence and severity of postoperative sore throat, cough, and hoarseness of voice, while simultaneously analyzing their role in perioperative hemodynamic and pulmonary parameters[30].

MATERIALS AND METHODS

This prospective, randomized, comparative study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment. The study was carried out in accordance with the principles of the Declaration of Helsinki.

A total of 90 adult patients scheduled for elective laparoscopic surgery under general anaesthesia with endotracheal intubation were included in the study. Patients were assessed during the pre-anaesthetic evaluation and those fulfilling the eligibility criteria were enrolled.

Inclusion Criteria

1. Age between 18 and 60 years
2. Either sex
3. American Society of Anesthesiologists (ASA) physical status I or II

4. Scheduled for elective laparoscopic surgery under general anaesthesia with endotracheal intubation
5. Expected duration of surgery less than 2 hours
6. Willingness to provide written informed consent

Exclusion Criteria
1. Pre-existing sore throat, cough, hoarseness of voice, or upper respiratory tract infection
2. Anticipated or documented difficult airway
3. Requirement of more than one attempt at intubation
4. History of chronic smoking, bronchial asthma, chronic obstructive pulmonary disease, or other chronic respiratory disorders
5. Known allergy or hypersensitivity to dexmedetomidine, ketamine, or magnesium sulphate
6. Use of steroids, NSAIDs, or analgesics within 24 hours prior to surgery
7. Pregnant or lactating women
8. Body mass index (BMI) > 30 kg/m²
9. Patients requiring nasogastric tube insertion or throat packing
10. Intraoperative complications requiring prolonged intubation or postoperative ventilation

Randomization and Group Allocation
Eligible patients were randomly allocated into three equal groups (n = 30 each) using a computer-generated random number table:

- Group A (Dexmedetomidine group): Nebulization with dexmedetomidine 50 µg diluted in 5 ml normal saline
- Group B (Magnesium sulphate group): Nebulization with magnesium sulphate 250 mg diluted in 5 ml normal saline
- Group C (Ketamine group): Nebulization with ketamine 50 mg diluted in 5 ml normal saline

Fifteen minutes before induction, nebulization was performed using a standard ultrasonic device.
Anaesthetic Technique

Fasting status was confirmed prior to patients entering the operating theatre, after which baseline measurements of heart rate, blood pressure, respiratory rate, and oxygen saturation were documented.Standard monitoring was instituted, including ECG, non-invasive blood pressure, pulse oximetry, and capnography.

General anaesthesia was induced using intravenous propofol and a suitable muscle relaxant to facilitate endotracheal intubation. A single attempt intubation was ensured using an appropriately sized cuffed endotracheal tube. Endotracheal tube cuff pressure was maintained within the recommended range. Anaesthesia was maintained with inhalational agents, oxygen, and muscle relaxants as required.

At the end of surgery, neuromuscular blockade was reversed and tracheal extubation was performed once the patient was fully awake and responding to verbal commands.

Outcome Assessment

Hemodynamic parameters (heart rate, systolic and diastolic blood pressure), respiratory rate, and oxygen saturation were recorded at predefined intervals throughout the perioperative period.

Postoperative airway-related complications were assessed at 1, 4, 6, and 24 hours after extubation, including:

- Postoperative sore throat (POST)
- Cough
- Hoarseness of voice

Each parameter was graded using a standardized four-point scale:

- Grade 0: None
- Grade 1: Mild
- Grade 2: Moderate
- Grade 3: Severe

Outcome measurements were obtained by an anaesthesiologist who remained blinded to group distribution.

Statistical Analysis
All data were tabulated in Microsoft Excel and processed using appropriate statistical tools. Numerical variables were expressed as mean ± standard deviation, and categorical variables were represented as frequencies and percentages. Group

comparisons employed relevant statistical techniques, and a p-value of less than 0.05 indicated statistical significance.

RESULTS

A total of 90 patients undergoing elective laparoscopic surgery under general anaesthesia with endotracheal intubation were included in the study and randomly allocated into three groups of 30 patients each. Group A received nebulized dexmedetomidine, Group B received nebulized magnesium sulphate, and Group C received nebulized ketamine. All patients completed the study, and no dropouts were recorded.

The age distribution of patients was comparable among the three groups, with the majority of patients belonging to the 31–40 years age group (40.0%), followed by the 41–50 years group (25.6%) and the 21–30 years group (21.1%). There was no statistically significant difference in age distribution between the groups ($p = 0.054$), indicating adequate demographic matching. Gender distribution was equal overall, with 45 males (50.0%) and 45 females (50.0%). The proportion of males and females was comparable across the three groups, and the difference was statistically non-significant ($p = 0.670$).

Hemodynamic parameters were monitored at multiple perioperative time points. Baseline heart rate, heart rate during nebulization, post-nebulization, pre-extubation, immediately after extubation, and at 4 and 6 hours postoperatively were comparable among the three groups, with no statistically significant differences ($p > 0.05$). However, at pre-intubation and immediately post-intubation, patients in Group B demonstrated significantly higher mean heart rates compared to Groups A and C ($p < 0.001$). In the early postoperative period, at 1 hour after extubation, Group B showed a significantly lower mean heart rate compared to the other two groups ($p = 0.003$). At 24 hours postoperatively, Group A exhibited a significantly lower mean heart rate than Groups B and C ($p = 0.038$).

Systolic blood pressure remained comparable among the three groups at baseline, during nebulization, post-nebulization, pre-intubation, post-intubation, pre-extubation, and at 4, 6, and 24 hours postoperatively, with no statistically significant differences ($p > 0.05$). Significant inter-group differences were observed immediately after extubation and at 1 hour postoperatively. Immediately after extubation, Group A had the highest mean systolic blood pressure, followed by Groups B and C ($p = 0.003$). At 1 hour postoperatively, Group B recorded the highest systolic blood pressure, followed by Group C and Group A, with the difference being statistically significant ($p = 0.003$).

Diastolic blood pressure values were comparable among the three groups from baseline through extubation, with no statistically significant differences ($p > 0.05$). Significant differences were observed in the postoperative period. At 4 hours postoperatively, Groups A and B demonstrated significantly higher mean diastolic blood pressure compared to Group C ($p = 0.004$). At 6 hours postoperatively, Group B had the highest mean diastolic blood pressure, followed by Groups A and C ($p = 0.040$). By 24 hours postoperatively, diastolic blood pressure values were comparable across all groups ($p = 0.325$).

Oxygen saturation remained excellent throughout the perioperative period in all three groups, with mean SpO_2 values consistently above 98%. No episode of clinically significant desaturation was observed in any patient. Although statistically significant differences were noted at post-intubation, pre-extubation, and 6 hours postoperatively, these differences were clinically insignificant.

Respiratory rate remained within normal physiological limits in all patients throughout the study period. At baseline, Group C demonstrated a slightly higher mean respiratory rate compared to Groups A and B, which was statistically significant ($p = 0.018$). However, following nebulization and at all subsequent intraoperative and postoperative time points, respiratory rates were comparable among the three groups ($p > 0.05$).

The incidence and severity of postoperative sore throat showed significant inter-group differences at all postoperative time points. At 1 hour after extubation, severe sore throat was most frequent in Group A, whereas Group B had the highest number of patients without sore throat ($p = 0.002$). At 4 and 6 hours post-extubation, Group B consistently demonstrated a significantly higher proportion of patients with complete resolution of sore throat compared to Groups A and C ($p = 0.001$ and $p = 0.006$, respectively). At 24 hours post-extubation, 63.3% of patients in Group B were completely symptom-free, compared with only 10.0% in Group A and 33.3% in Group C ($p = 0.001$).

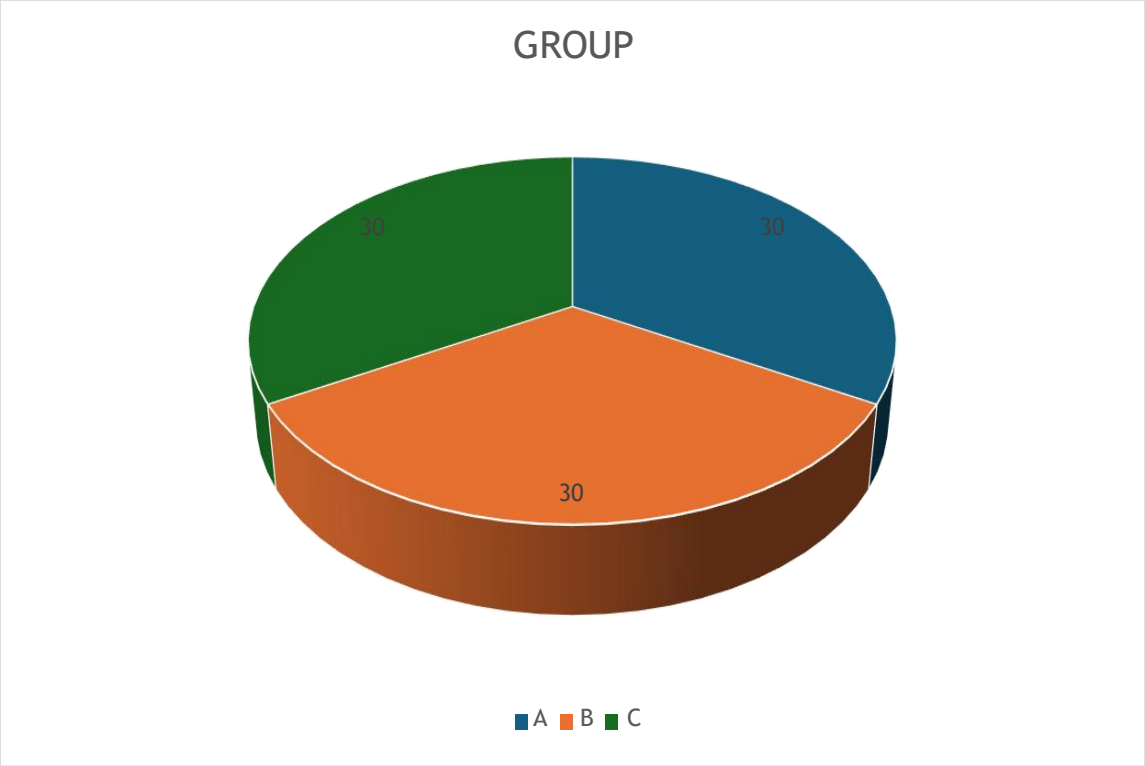
Postoperative cough followed a similar pattern. At 1 hour post-extubation, cough of any grade was significantly more common in Group A compared to Groups B and C ($p = 0.004$). At 4 and 6 hours, Group B showed a markedly higher number of cough-free patients, with the difference being highly significant ($p = 0.003$ and $p < 0.001$, respectively). By 24 hours post-extubation, 80.0% of patients in Group B were free of cough, compared to 40.0% in Group A and 60.0% in Group C ($p = 0.020$).

Hoarseness of voice was also significantly reduced in the magnesium sulphate group. At 1 hour post-extubation, hoarseness of any grade was most frequent in Group C and least frequent in Group B ($p = 0.007$). At 4, 6, and 24 hours, Group B consistently demonstrated a significantly higher proportion of patients with complete resolution of hoarseness compared to Groups A and C ($p = 0.021$, $p = 0.018$, and $p = 0.035$, respectively).

Overall, pre-operative nebulization with magnesium sulphate was associated with a significantly lower incidence and severity of postoperative sore throat, cough, and hoarseness of voice, while maintaining stable hemodynamic and respiratory parameters throughout the perioperative period.

Table1.Distributionofgroups

GROUP	No. ofPatients(n=90)
A	30
B	30
C	30



Graph1.Distributionofgroups

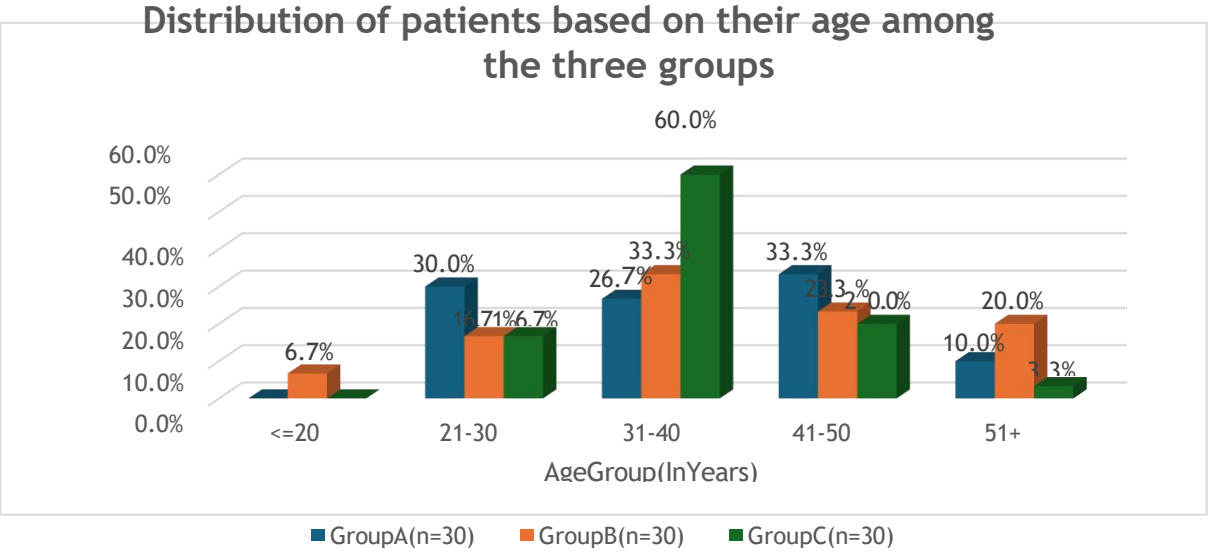
In our study, the largest age group overall was 31–40 years (36 patients, 40.0%), followed by 41–50 years (23 patients, 25.6%) and 21–30 years (19 patients, 21.1%).

In Group A (dexmedetomidine, n=30), 9 patients (30.0%) were aged 21–30 years, 8 patients (26.7%) were 31–40 years, 10 patients (33.3%) were 41–50 years, 3 patients (10.0%) were above 50 years, and no patient was aged 20 years or younger.InGroupB(magnesiumsulfate,n=30),5patients(16.7%)wereaged21–30years,10patients (33.3%)were31–40years,7patients(23.3%)were41–50years,6patients(20.0%)wereabove
50years, and2 patients(6.7%) wereaged 20yearsor younger.In Group C (ketamine, n=30), 5 patients (16.7%) belonged to the 21–30 years category, 18 patients(60.0%)were31–40years,6patients(20.0%)were41–50years,1patient(3.3%)was above 50 years, and none was aged 20 years or younger.The age distribution of the ninety patients was comparable across the three groups with no statistically significant difference (p=0.054).

Table2.Distributionofstudiedpatientsbasedontheirageamongthethreegroups

Age(InYears)	DRUG			Total	p-value
	GroupA(n=30)	GroupB(n=30)	GroupC(n=30)		
<= 20	0 (0.0%)	2 (6.7%)	0 (0.0%)	2 (2.2%)	

21 -30	9 (30.0%)	5 (16.7%)	5 (16.7%)	19 (21.1%)	0.054
31 -40	8 (26.7%)	10 (33.3%)	18 (60.0%)	36 (40.0%)	
41 -50	10 (33.3%)	7 (23.3%)	6 (20.0%)	23 (25.6%)	
51+	3 (10.0%)	6 (20.0%)	1 (3.3%)	10 (11.1%)	



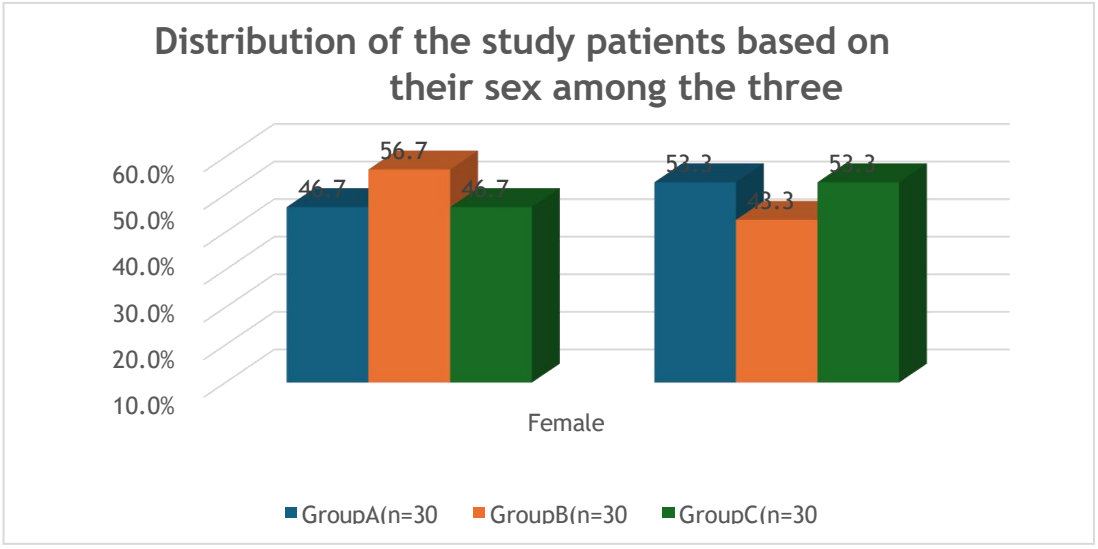
Graph2. Distributionofstudiedpatientsbasedontheirageamongthethreegroups

In our study, the study population consisted of 45 females (50.0%) and 45 males (50.0%). In Group A(dexmedetomidine,n=30),14 patients (46.7%)werefemale and 16 patients (53.3%) were male. In Group B (magnesium sulfate, n=30), 17 patients (56.7%) were female and 13 patients (43.3%) were male. In Group C (ketamine, n=30), 14 patients (46.7%) were female and 16 patients (53.3%) were male.

Overall, the gender distribution among the ninety patients was statistically non-significant across the three groups (p=0.670).

Table3.Distributionofstudiedpatientsbasedontheirgenderamongthethreegroups

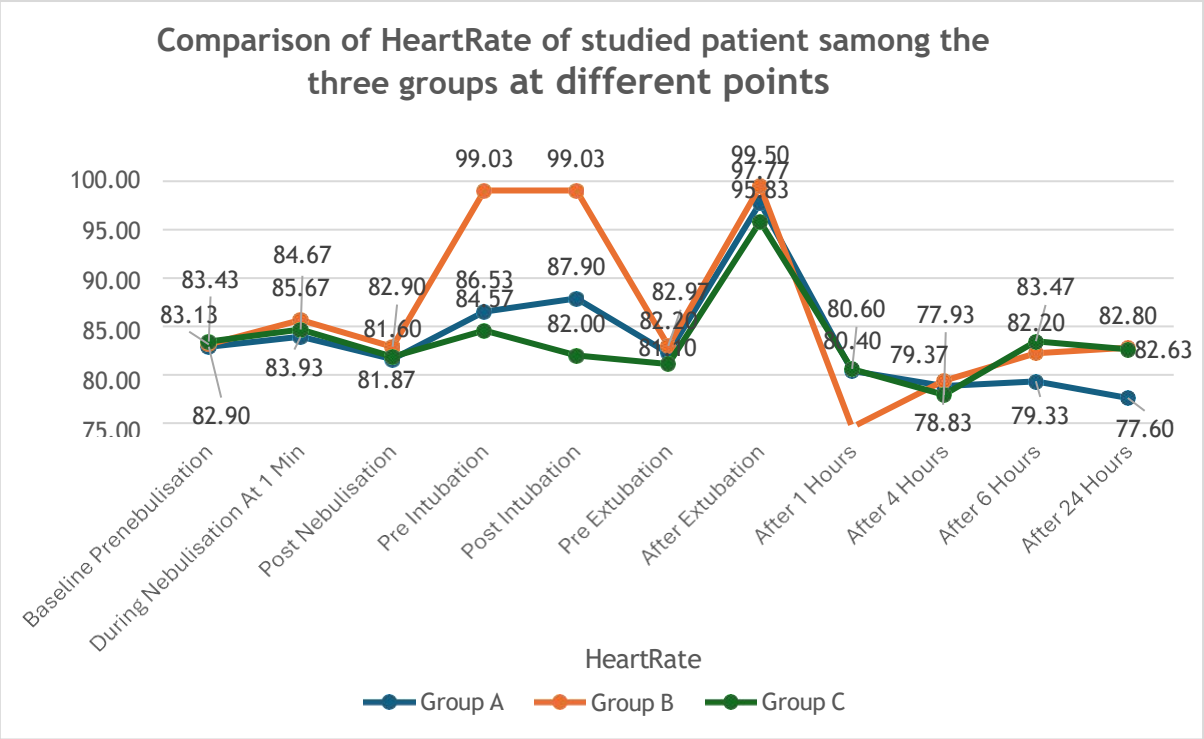
Sex	**DRUG**			**Total**	**p-Value**
	GroupA	**GroupB**	**GroupC**		
Female	14 (46.7%)	17 (56.7%)	14 (46.7%)	45 (50.0%)	0.670
Male	16 (53.3%)	13 (43.3%)	16 (53.3%)	45 (50.0%)	



Graph3.Distributionofstudiedpatientsbasedontheirgenderamongthethreegroups

Table4.ComparisonofHeartRateofpatientsamongthethreegroupsatdifferentpoints

HR	Group A (Mean±SD)	Group B (Mean±SD)	Group C (Mean±SD)	TOTAL	p- Value
BaselinePrenebulisation	82.90±10.63	83.13±9.41	83.43±12.54	83.16±10.81	0.982
DuringNebulisationAt1 Min	83.93±10.35	85.67±10.11	84.67±11.65	84.76±10.63	0.821
PostNebulisation	81.60±9.82	82.90±10.63	81.87±9.83	82.12±10.00	0.871
PreIntubation	86.53±12.72	99.03±0.61	84.57±10.99	90.04±11.56	0.000
PostIntubation	87.90±11.75	99.03±0.61	82.00±11.06	89.64±11.64	0.000
PreExtubation	82.20±10.22	82.97±9.90	81.10±10.47	82.09±10.12	0.777
AfterExtubation	97.77±11.83	99.50±10.33	95.83±12.79	97.70±11.66	0.481
After1Hours	80.40±6.62	74.57±7.88	80.60±8.04	78.52±7.97	0.003
After4Hours	78.83±9.40	79.37±7.69	77.93±4.51	78.71±7.42	0.756
After6Hours	79.33±6.55	82.20±9.26	83.47±8.64	81.67±8.32	0.144
After24Hours	77.60±8.29	82.80±9.08	82.63±8.95	81.01±9.01	0.038



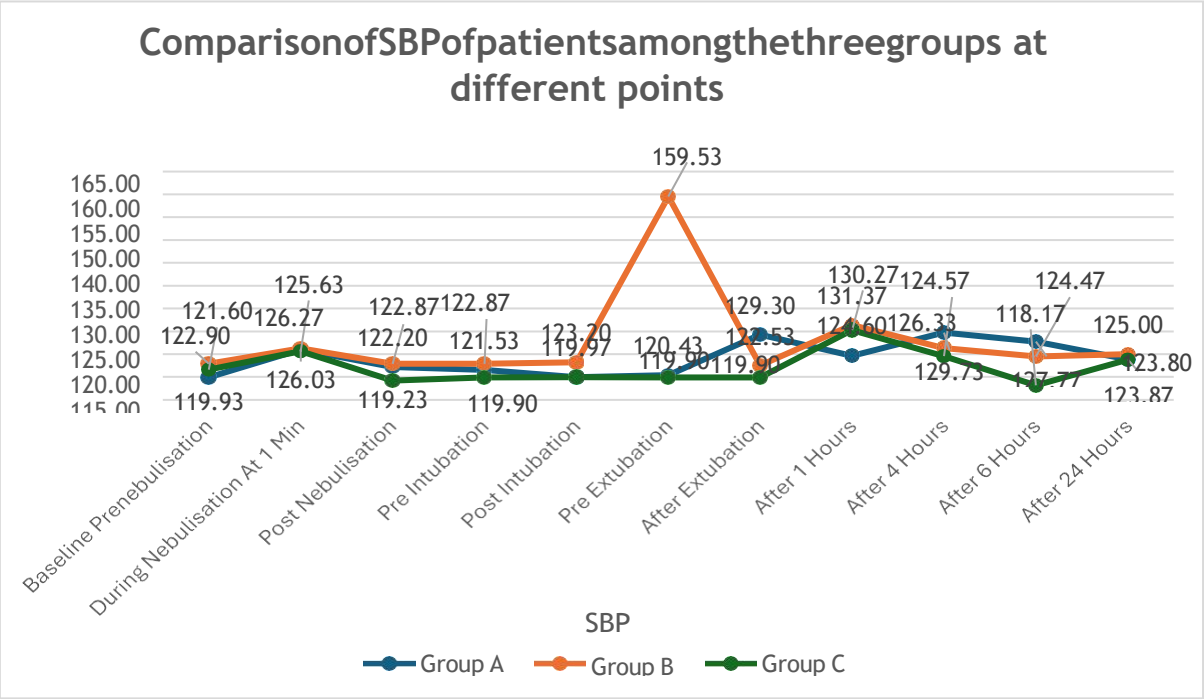
Graph4. ComparisonofHeartRateofpatientsamongthethreegroupsatdifferentpoints

In our study, systolic blood pressure (SBP) remained comparable among the three groups at baseline (prenebulization), during and immediately after nebulization, pre-intubation, post- intubation, pre-extubation, and at 4, 6, and 24 hours postoperatively, with no statistically significant differences ($p > 0.05$ at all these time points).The only periods in which significant inter-group differences were observed occurred immediately after extubation and at 1 hour postoperatively. Immediately after extubation, patients in Group A (dexmedetomidine) exhibited the highest mean SBP (129.30 ± 11.37 mmHg), followed by Group B (magnesium sulfate; 122.53 ± 10.55 mmHg) and Group C (ketamine; 119.90 ± 9.55 mmHg), with a significant p-value of 0.003.

Similarly, at 1 hour postoperatively,GroupBrecordedthehighestmeanSBP(131.37±6.75mmHg),followedby Group C (130.27 ± 7.63 mmHg) and Group A (124.60 ± 9.57 mmHg; p = 0.003).

Table5.ComparisonofSBPofpatientsamongthethreegroupsatdifferentpoints

SBP	Group A (Mean±SD)	Group B (Mean±SD)	Group C (Mean±SD)	TOTAL	p- Value
Baseline Prenebulisation	119.93±10.208	122.90±10.633	121.60±9.372	121.48±10.045	0.523
DuringNebulisation At 1 Min	126.03±7.797	126.27±7.900	125.63±7.313	125.98±7.592	0.949
PostNebulisation	122.20±8.471	122.87±10.628	119.23±9.591	121.43±9.627	0.301
PreIntubation	121.53±10.497	122.87±10.628	119.90±9.550	121.43±10.194	0.534
PostIntubation	119.97±22.707	123.20±10.364	119.97±9.557	121.04±15.334	0.646
PreExtubation	120.43±8.029	159.53±203.202	119.90±9.550	133.29±117.700	0.330
AfterExtubation	129.30±11.372	122.53±10.553	119.90±9.550	123.91±11.135	0.003
After1Hours	124.60±9.569	131.37±6.749	130.27±7.634	128.74±8.518	0.003
After4Hours	129.73±7.441	126.33±7.237	124.57±22.860	126.88±14.493	0.378
After6Hours	127.77±7.094	124.47±7.722	118.17±30.349	123.47±18.761	0.132
After24Hours	123.87±8.537	125.00±9.033	123.80±8.708	124.22±8.680	0.837



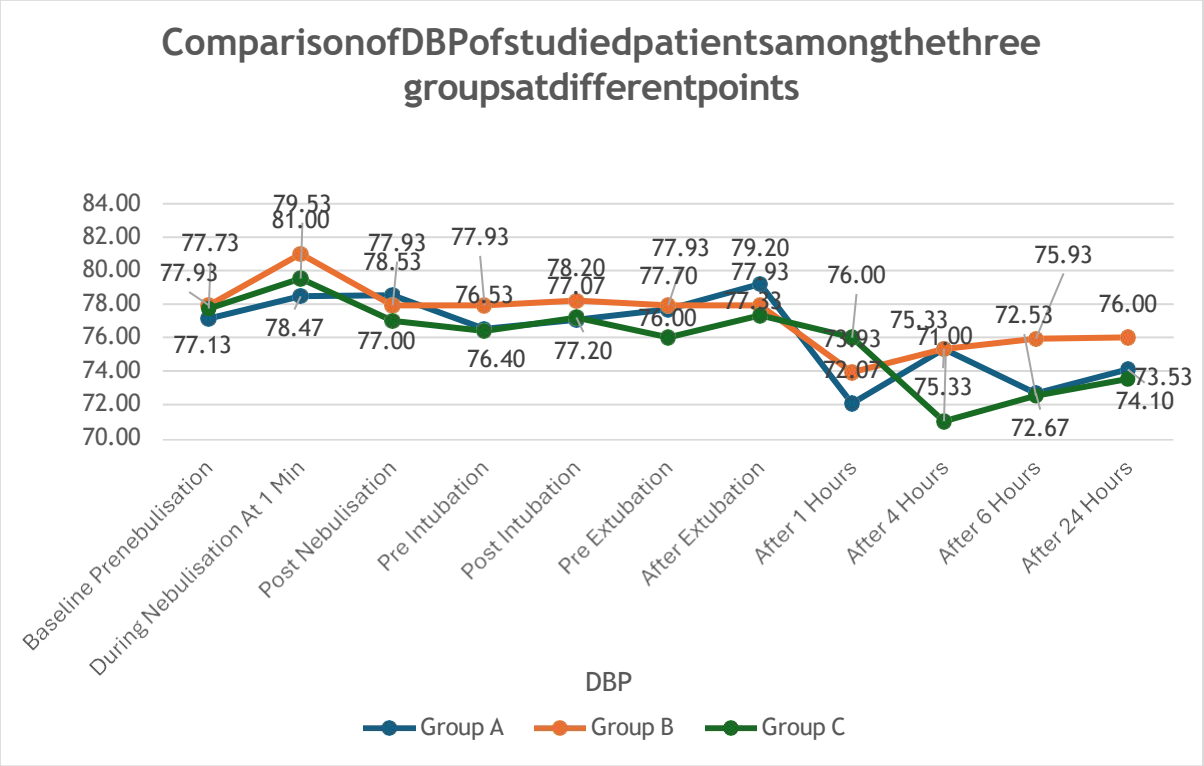
Graph5.ComparisonofSBPofpatientsamongthethreegroupsatdifferentpoints

In our study, diastolic blood pressure (DBP) remained comparable among the three groups from baseline through pre-extubation, during and after nebulization, pre- and post-intubation, and immediately after extubation, with no statistically significant differences (p > 0.05 at all these time points).Significant inter-group differences emerged in the postoperative period. At 4 hours postoperatively, mean DBP was highest in Group A (dexmedetomidine) and Group B (magnesium sulfate) at 75.33 ±

6.27 mmHg and 75.33 ± 6.20 mmHg respectively, and significantlylowerinGroupC(ketamine)at71.00±4.48mmHg(p=0.004).Asimilarpattern persisted at 6 hours postoperatively, whereGroup B recorded the highest mean DBP (75.93 ± 6.16 mmHg), followed by Group A(72.67 ± 5.47mmHg)and Group C (72.53 ± 5.68mmHg; p = 0.040). By 24 hours,the differences had resolved, with mean DBP values of 74.10 ± 6.63 mmHginGroupA,76.00±7.07mmHginGroupB,and73.53±6.16mmHginGroupC(p= 0.325).

Table6.ComparisonofDBPofpatientsamongthethreegroupsatdifferentpoints

DBP	Group A (Mean±SD)	Group B (Mean±SD)	Group C (Mean±SD)	TOTAL	p- Value
Baseline Prenebulisation	77.13±8.609	77.93±8.967	77.73±8.497	77.60±8.602	0.934
DuringNebulisation At 1 Min	78.47±7.371	81.00±7.887	79.53±7.186	79.67±7.476	0.424
PostNebulisation	78.53±8.403	77.93±8.967	77.00±8.847	77.82±8.667	0.792
PreIntubation	76.53±8.341	77.93±8.967	76.40±7.885	76.96±8.344	0.737
PostIntubation	77.07±7.451	78.20±8.903	77.20±8.876	77.49±8.358	0.851
PreExtubation	77.70±8.099	77.93±8.967	76.00±8.052	77.21±8.334	0.623
AfterExtubation	79.20±6.935	77.93±8.967	77.33±8.841	78.16±8.243	0.675
After1Hours	72.07±6.247	73.93±5.930	76.00±7.391	74.00±6.677	0.073
After4Hours	75.33±6.266	75.33±6.200	71.00±4.480	73.89±6.006	0.004
After6Hours	72.67±5.467	75.93±6.158	72.53±5.680	73.71±5.925	0.040
After24Hours	74.10±6.630	76.00±7.066	73.53±6.163	74.54±6.640	0.325

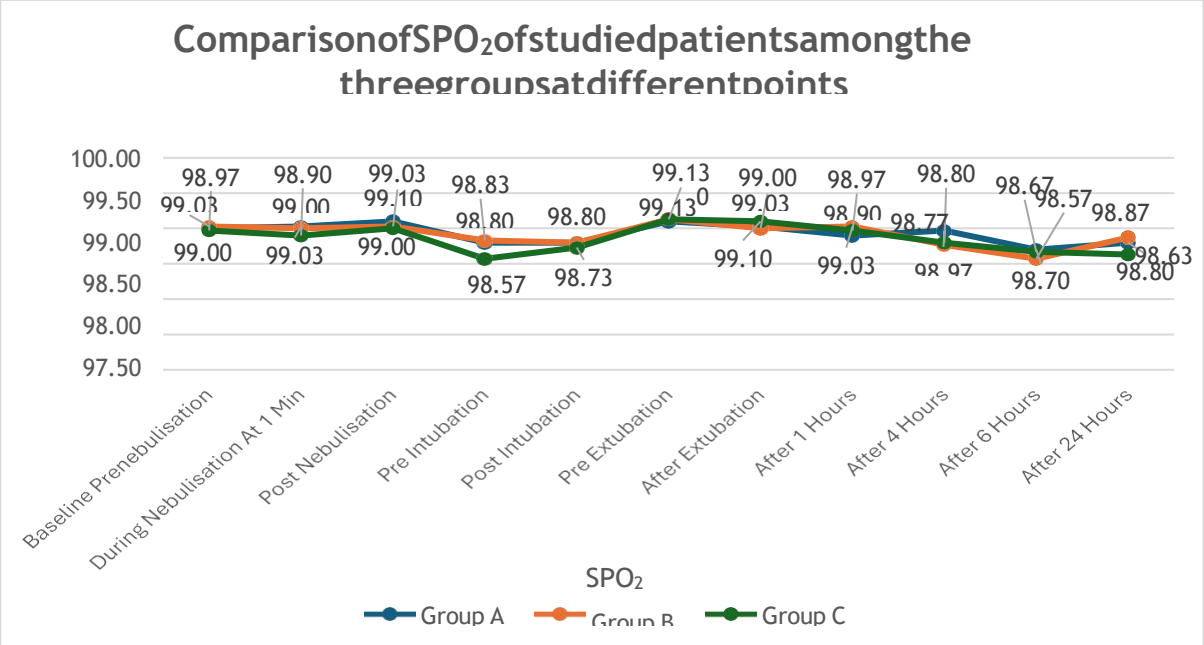


Graph6.ComparisonofDBPofpatientsamongthethreegroupsatdifferentpoints

Inourstudy,oxygensaturation(SpO)remainedexcellent(>98%)throughouttheperioperative periodinallthreegroups,withnoepisodeofclinicallysignificantdesaturationrecordedinany patient. Mean SpO values were comparable across the groups at almost all time points. Statistically significant differences were observed at three time points: Immediatelypost-intubation,meanSpO₂wasslightlyhigherinGroupA(98.80±0.997%)and Group B (98.80 ± 1.095%) compared with Group C (98.73 ± 1.048%; p = 0.041). At pre- extubation, Group B and Group C both recorded 99.13 ± 0.730% versus 99.10 ± 0.712% in Group A (p = 0.021). At 6 hours postoperatively, mean SpO was marginally higherin Group A (98.70 ± 2.152%) than in Group B (98.57 ± 2.128%; p = 0.031).

Table7.ComparisonofSPO2ofpatientsamongthethreegroupsatdifferentpoints

SPO2	Group A (Mean±SD)	Group B (Mean±SD)	Group C (Mean±SD)	TOTAL	p- Value
BaselinePre-nebulisation	99.00±0.643	99.03±0.615	98.97±0.669	99.00±0.636	0.081
DuringNebulisationAt1 Min	99.03±0.615	99.00±0.643	98.90±0.607	98.98±0.618	0.373
PostNebulisation	99.10±0.712	99.03±0.615	99.00±.643	99.04±0.652	0.180
PreIntubation	98.80±0.847	98.83±0.874	98.57±.971	98.73±0.897	0.783
PostIntubation	98.80±0.997	98.80±1.095	98.73±1.048	98.78±1.036	0.041
PreExtubation	99.10±0.712	99.13±0.730	99.13±0.730	99.12±0.716	0.021
AfterExtubation	99.03±0.718	99.00±0.743	99.10±0.759	99.04±0.733	0.142
After1Hour	98.90±0.759	99.03±0.669	98.97±0.718	98.97±0.710	0.260
After4Hours	98.97±0.765	98.77±0.728	98.80±0.761	98.84±0.748	0.610
After6Hours	98.70±2.152	98.57±2.128	98.67±2.171	98.64±2.127	0.031
After24Hours	98.80±0.714	98.87±0.629	98.63±0.669	98.77±0.671	0.961



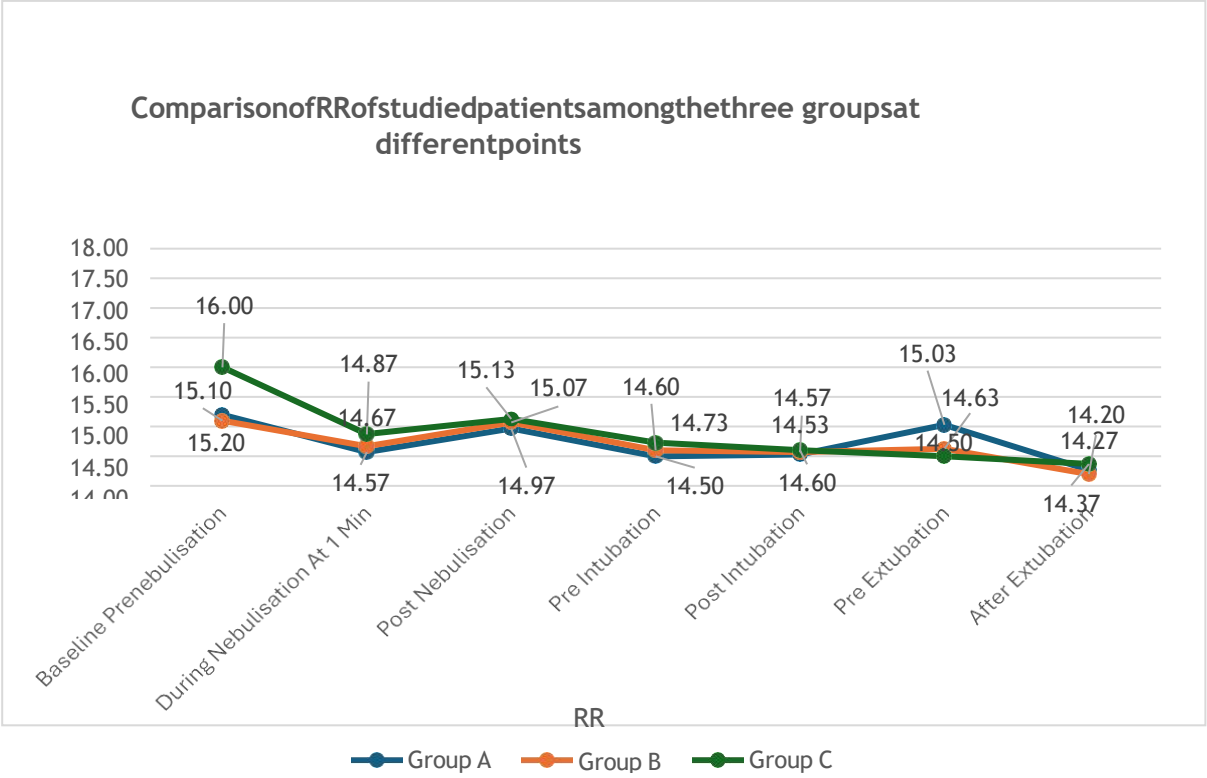
Graph7.ComparisonofSPO2ofpatientsamongthethreegroupsatdifferentpoints

In our study, respiratory rate (RR) remained within the normal range (12–18 breaths per minute) throughout the perioperative period in all three groups.

"At baseline (prenebulization), a statistically significant difference was observed (p=0.018): patients in Group C (ketamine) had a slightly higher mean RR of 16.00 ± 1.84 breaths/min compared with 15.20 ± 0.93 in Group A (dexmedetomidine) and 15.10 ± 1.00 in Group B (magnesium sulfate)". However, after completion of nebulization and at all subsequent time points during and post-nebulization, pre-intubation, post-intubation, pre-extubation, and immediately after extubation the mean respiratory rates were highly comparable among the three groups, with no significant differences (p > 0.05).

Table8.ComparisonofRRofpatientsamongthethreegroupsatdifferentpoints

RR	Group A (Mean±SD)	Group B (Mean±SD)	Group C (Mean±SD)	TOTAL	p- Value
BaselinePrenebulisation	15.20±0.925	15.10±0.995	16.00±1.838	15.43±1.366	0.018
DuringNebulisationAt1 Min	14.57±1.165	14.67±1.241	14.87±1.570	14.70±1.328	0.677
PostNebulisation	14.97±0.850	15.07±0.828	15.13±1.042	15.06±0.904	0.776
PreIntubation	14.50±1.167	14.60±1.003	14.73±1.311	14.61±1.158	0.740
PostIntubation	14.53±1.252	14.57±1.165	14.60±1.248	14.57±1.209	0.978
PreExtubation	15.03±1.629	14.63±1.098	14.50±1.009	14.72±1.281	0.247
AfterExtubation	14.27±1.048	14.20±1.157	14.37±1.129	14.28±1.102	0.843



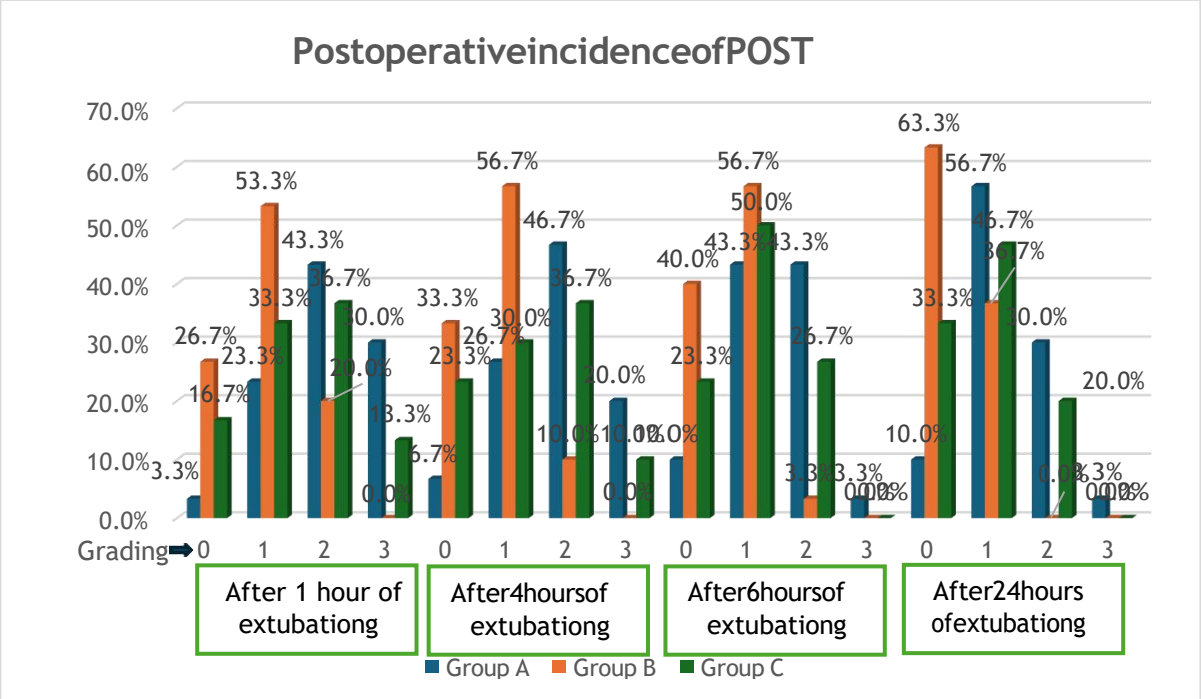
Graph8.ComparisonofRRofpatientsamongthethreegroupsatdifferentpoints

In ourstudy, theincidenceand severityofpostoperativesorethroat(POST)werevaluated at 1,4,6,and24hoursafterextubationusingafour-pointscale(0=nosorethroat,1=mild,2= moderate, 3 = severe). "At 1-hour post-extubation, only 1 patient (3.3%) in Group A reported no sore throat, whereas 8 patients (26.7%) in Group B and 5 patients (16.7%) in Group C were symptom-free (p=0.002)".Severe(grade3)POSTwasmostfrequentinGroupA,affecting9patients(30.0%), compared with none in Group B and 4 patients (13.3%) in Group C.
"At4hours,theadvantageshiftedtowardGroupB:10patients(33.3%)inGroupBhadnosore throat compared with only 2 patients (6.7%) in Group A and 7 patients (23.3%) in Group C (p=0.001)". SeverePOST persisted in 6 patients (20.0%)in Group A and 3

patients (10.0%)in Group C, but none in Group B.At6hours,completeresolutionwasobservedin12patients(40.0%)inGroupB,significantly higher than 3 patients (10.0%) in Group A and 7 patients (23.3%) in Group C (p=0.006). Moderate sore throat affected 13 patients (43.3%) in Group A versus only 1 patient (3.3%) in Group B, with no severe cases in any group.By 24 hours post-extubation, the differences were most striking (p=0.001). Complete relief from sore throat was achieved in 19 patients (63.3%) in Group B, in contrast to 3 (10.0%) and 10 (33.3%) patients in Groups A and C, respectively. Moderate POST persisted among 9 patients (30.0%) in Group A and 6 (20.0%) in Group C, whereas no such cases occurred in Group B. Severe POST was documented in only 1 patient (3.3%) in Group A.

Table9.Postoperativeincidenceof POST

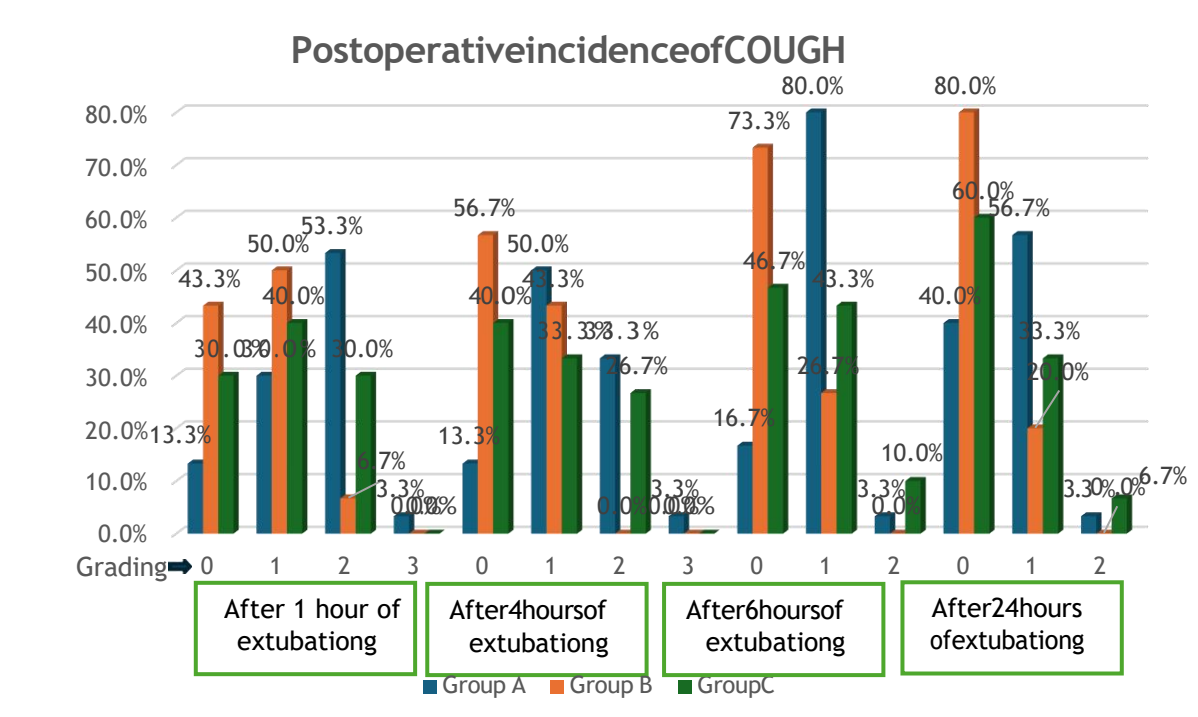
POST		GroupA	GroupB	GroupC	P-value
	Grading	Frequency (%)	Frequency (%)	Frequency (%)	
After1Hourof Extubating	0	1 (3.3)	8 (26.7)	5 (16.7)	0.002
	1	7 (23.3)	16 (53.3)	10 (33.3)	
	2	13 (43.3)	6 (20.0)	11 (36.7)	
	3	9 (30.0)	0 (0.0)	4 (13.3)	
After4HoursofExtubating	0	2 (6.7)	10 (33.3)	7 (23.3)	0.001
	1	8 (26.7)	17 (56.7)	9 (30.0)	
	2	14 (46.7)	3 (10.0)	11 (36.7)	
	3	6 (20.0)	0 (0.0)	3 (10.0)	
After6HoursofExtubating	0	3 (10.0)	12 (40.0)	7 (23.3)	0.006
	1	13 (43.3)	17 (56.7)	15 (50.0)	
	2	13 (43.3	1 (3.3)	8 (26.7)	
	3	1 (3.3)	0 (0.0)	0 (0.0)	
After24Hoursof Extubating	0	3 (10.0)	19 (63.3)	10 (33.3)	0.001
	1	17 (56.7)	11 (36.7)	14 (46.7)	
	2	9 (30.0)	0 (0.0)	6 (20.0)	
	3	1 (3.3)	0 (0.0)	0 (0.0)	



Graph9.PostoperativeincidenceofPOST

Table10.PostoperativeincidenceofCOUGH

COUGH		GroupA	GroupB	GroupC	P-value
	Grading	Frequency (%)	Frequency (%)	Frequency (%)	
After1Hourof Extubating	0	4 (13.3)	13 (43.3)	9 (30.0)	0.004
	1	9 (30.0)	15 (50.0)	12 (40.0)	
	2	16 (53.3)	2 (6.7)	9 (30.0)	
	3	1 (3.3)	0 (0.0)	0 (0.0)	
After4HoursofExtubating	0	4 (13.3)	17 (56.7)	12 (40.0)	0.003
	1	15 (50.0)	13 (43.3)	10 (33.3)	
	2	10 (33.3)	0 (0.0)	8 (26.7)	
	3	1 (3.3)	0 (0.0)	0 (0.0)	
After6HoursofExtubating	0	5 (16.7)	22 (73.3)	14 (46.7)	0.000
	1	24 (80.0)	8 (26.7)	13 (43.3)	
	2	1 (3.3)	0 (0.0)	3 (10.0)	
After24Hoursof Extubating	0	12 (40.0)	24 (80.0)	18 (60.0)	0.020
	1	17 (56.7)	6 (20.0)	10 (33.3)	
	2	1 (3.3)	0 (0.0)	2 (6.7)	



Graph10.PostoperativeincidenceofCOUGH

Table11.PostoperativeincidenceofHOARSENESS

HOARSENESS		GroupA	GroupB	GroupC	P-value
	Grading	Frequency (%)	Frequency (%)	Frequency (%)	
	0	7 (23.3)	11 (36.6)	4 (13.3)	
	1	8 (26.7)	17 (56.7)	11 (36.7)	

After1Hourof Extubating	2	13 (43.3)	2 (6.7)	12 (40.0)	**0.007**
	3	2 (6.7)	0 (0.0)	3 (10.0)	
After4HoursofExtubating	0	8 (26.7)	15 (50.0)	6 (20.0)	**0.021**
	1	12 (40.0)	15 (50.0)	14 (46.7)	
	2	9 (30.0)	0 (0.0)	9 (30.0)	
	3	1 (3.3)	0 (0.0)	1 (3.3)	
After6HoursofExtubating	0	11 (36.7)	19 (63.3)	8 (26.7)	**0.018**
	1	16 (53.3)	11 (36.7)	16 (53.3)	
	2	2 (6.7)	0 (0.0)	6 (20.0)	
	3	1 (3.3)	0 (0.0)	0 (0.0)	
After24Hoursof Extubating	0	11 (36.7)	22 (73.3)	13 (43.3)	**0.035**
	1	18 (60.0)	8 (26.7)	15 (50.0)	
	2	1 (3.3)	0 (0.0)	2 (6.7)	

DISCUSSION

Postoperative sore throat (POST) is a frequent and distressing complication following general anaesthesia with endotracheal intubation, with reported incidence ranging from 14.4% to over 50% depending on patient characteristics, airway instrumentation, and duration of intubation [1–3]. Although POST is generally self-limiting, it significantly impacts postoperative comfort, patient satisfaction, and perceived quality of anaesthetic care [4]. Therefore, prevention of POST has gained increasing attention in recent years.

The pathophysiology of POST is multifactorial and includes mechanical trauma to the airway mucosa during laryngoscopy and intubation, pressure-induced ischemia from the endotracheal tube cuff, mucosal inflammation, and dryness caused by inhalational agents [5–7]. Additional risk factors such as female gender, prolonged surgical duration, larger endotracheal tube size, repeated intubation attempts, and high cuff pressure further increase the likelihood of POST [8,9].

In the present study, pre-operative nebulization with magnesium sulphate demonstrated a significant reduction in the incidence and severity of POST compared with dexmedetomidine and ketamine at all postoperative assessment intervals. At 1, 4, 6, and 24 hours after extubation, a significantly higher proportion of patients in the magnesium sulphate group were completely free of sore throat. These findings are consistent with earlier studies reporting the efficacy of magnesium sulphate nebulization in reducing POST by suppressing airway inflammation and nociceptive transmission [10–12].

Magnesium sulphate exerts its beneficial effects primarily through antagonism of N-methyl-D-aspartate (NMDA) receptors and blockade of calcium channels, resulting in decreased neurotransmitter release and attenuation of inflammatory responses [13,14]. When administered via nebulization, magnesium acts locally on the airway mucosa, reducing edema, irritation, and smooth muscle spasm without producing significant systemic effects [15]. This localized mechanism explains the superior efficacy and favorable safety profile observed in our study.

Dexmedetomidine, a highly selective α-2 adrenergic agonist, has been widely studied for its sedative, analgesic, and anti-inflammatory properties [16]. Nebulized dexmedetomidine has been shown to reduce airway reflexes and attenuate sympathetic responses during airway manipulation [17,18]. In the present study, dexmedetomidine nebulization resulted in partial reduction of POST; however, its efficacy was inferior to magnesium sulphate. This may be attributed to its predominant central sympatholytic action rather than a strong local anti-inflammatory effect on airway mucosa [19].

Ketamine nebulization showed moderate efficacy in reducing POST compared with dexmedetomidine but was less effective than magnesium sulphate. Ketamine acts as an NMDA receptor antagonist and possesses potent anti-hyperalgesic properties [20]. Topical and nebulized ketamine has been reported to reduce POST by decreasing peripheral sensitization and inflammatory responses [21,22]. However, ketamine may itself cause mild airway irritation, which could explain the persistence of postoperative symptoms in some patients, particularly in the early postoperative period [23].

Postoperative cough is another common airway-related complication that results from irritation of tracheobronchial receptors and residual airway inflammation following intubation [24]. In our study, nebulized magnesium sulphate significantly reduced both the incidence and severity of postoperative cough compared with dexmedetomidine and ketamine at all postoperative time points. The bronchodilatory and smooth muscle–relaxant properties of magnesium are well established and likely contribute to this protective effect [25].

Hoarseness of voice, caused by vocal cord edema, mucosal trauma, and laryngeal inflammation, is frequently reported following endotracheal intubation [26]. In the present study, the magnesium sulphate group demonstrated significantly faster and more complete resolution of hoarseness of voice compared with the other two groups. This finding supports previous reports suggesting that magnesium effectively reduces laryngeal inflammation and mucosal edema when administered topically or via nebulization [27].

Hemodynamic stability is a critical consideration when evaluating any prophylactic intervention in the perioperative period. In our study, heart rate and blood pressure remained largely comparable among the three groups throughout the perioperative period, with only transient and clinically insignificant variations at certain time points. Importantly, nebulized magnesium sulphate did not produce hypotension, bradycardia, or respiratory depression, confirming its cardiovascular safety [28].

Oxygen saturation remained consistently above 98% in all patients, and no episodes of clinically significant desaturation were observed. Respiratory rate also remained within normal physiological limits in all groups, indicating that nebulized dexmedetomidine, ketamine, and magnesium sulphate are safe from a respiratory standpoint when used in appropriate doses [29].

In a study by Puri et al. (2025) conducted a systematic review and meta-analysis on the effectiveness of nebulized dexmedetomidine in reducing postoperative sore throat, showing it significantly decreased the incidence of POST at 2, 12, and 24 hours compared with placebo and other comparators [30].

A study by Mehra et al. (2025) reported findings from a comparative clinical study indicating that nebulization with dexmedetomidine resulted in a significantly lower incidence and less severe postoperative sore throat than nebulized clonidine in patients undergoing elective laparoscopic cholecystectomy under general anaesthesia [31].

The strengths of the present study include its randomized design, standardized anaesthetic protocol, uniform assessment of postoperative airway complications using validated grading scales, and comprehensive perioperative monitoring.However, the study has certain limitations, including its single-center design, restricted participant number, and inclusion of only short laparoscopic operations. Additionally, biochemical markers of airway inflammation were not assessed, which could have provided further mechanistic insight [32].

Despite these limitations, the findings of this study strongly support the use of pre-operative nebulized magnesium sulphate as an effective, safe, and inexpensive strategy for reducing postoperative sore throat, cough, and hoarseness of voice in patients undergoing general anaesthesia with endotracheal intubation.

CONCLUSION

Postoperative sore throat, cough, and hoarseness of voice remain common and uncomfortable complications following general anaesthesia with endotracheal intubation. The present randomized comparative study demonstrates that pre-operative nebulization with magnesium sulphateis significantly more effective than nebulized dexmedetomidine and ketamine in reducing how often and how severely patients experienced postoperative sore throat, cough, and hoarseness throughout the assessment periodup to 24 hours.

Nebulized magnesium sulphate provided superior airway protection with earlier symptom resolution and a higher proportion of symptom-free patients, without causing clinically significant hemodynamic or respiratory adverse effects. Dexmedetomidine and ketamine showed moderate efficacy but were inferior to magnesium sulphate in controlling postoperative airway morbidity. Given its ease of administration, cost-effectiveness, favorable safety profile, and superior clinical efficacy, pre-operative nebulized magnesium sulphate can be recommended as an effective prophylactic intervention for reducing postoperative airway-related complications in patients undergoing laparoscopic surgery under general anaesthesia with endotracheal intubation.

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