RESEARCH PAPER

Nebulized Dexamethasone Versus Magnesium Sulfate for Prevention of Postoperative Sore Throat After Endotracheal Intubation: A Randomized Double-Blind Placebo-Controlled Trial

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ABSTRACT

Background: Postoperative sore throat (POST) is a frequent complication after endotracheal intubation and remains an important cause of patient discomfort. Nebulized dexamethasone and magnesium sulfate have both been investigated for prophylaxis; however, direct comparisons between these agents are limited.

Objective: To compare the effectiveness of preoperative nebulized dexamethasone, nebulized magnesium sulfate, and placebo in preventing postoperative sore throat, cough, and hoarseness following endotracheal intubation.

Methods: This prospective, randomized, double-blind, placebo-controlled trial included 90 ASA physical status I–II patients aged 18–60 years undergoing elective surgery under general anesthesia with endotracheal intubation. Participants were randomized equally to receive nebulized dexamethasone 8 mg (Group A), nebulized magnesium sulfate 50% (2 mL) (Group B), or 5 mL normal saline (Group C) 30 minutes before induction. The primary outcome was the incidence of POST during the first 24 postoperative hours. Secondary outcomes included cough, hoarseness, perioperative hemodynamic parameters, and adverse effects.

Results: Baseline demographic characteristics, duration of laryngoscopy, duration of surgery, and perioperative hemodynamic variables were comparable among the three groups (all $p>0.05$). The incidence of POST was significantly lower in the dexamethasone group than in the magnesium sulfate and placebo groups at 0, 4, 8, and 12 hours after extubation (all $p<0.05$). Overall POST occurred in 30.0% of patients receiving dexamethasone, compared with 76.7% in the magnesium sulfate group and 100% in the placebo group. Similar reductions were observed for postoperative cough (6.7%, 33.3%, and 83.3%, respectively) and hoarseness (6.7%, 46.7%, and 73.3%, respectively). Symptoms had largely resolved by 24 hours, with no significant intergroup differences. No clinically significant hemodynamic instability or serious adverse events were observed.

Conclusion: Preoperative nebulized dexamethasone provided greater protection against postoperative sore throat, cough, and hoarseness than nebulized magnesium sulfate or placebo without affecting perioperative hemodynamic stability.

Keywords: Postoperative Sore Throat, Dexamethasone, Magnesium Sulfate, Endotracheal Intubation, Nebulizers and Vaporizers

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INTRODUCTION

Securing the airway with an endotracheal tube (ETT) remains the standard of care for patients undergoing general anesthesia, providing reliable airway protection and controlled ventilation during surgery. Despite its widespread use and clinical advantages, endotracheal intubation is frequently associated with postoperative airway morbidity, the most common complication being postoperative sore throat (POST).[1] POST results from mechanical trauma to the pharyngeal and laryngotracheal mucosa during laryngoscopy, passage of the endotracheal tube, cuff-related mucosal compression, tube movement during surgery, and extubation, leading to localized inflammation, edema, and irritation.[2]

The reported incidence of POST ranges from 21% to 65%, depending on patient characteristics, airway instrumentation, tube size, cuff pressure, duration of surgery, and assessment methods.[3] Although generally self-limiting, POST is consistently ranked among the most undesirable postoperative complaints by patients because it causes discomfort, impairs swallowing and phonation, delays return to normal oral intake, and negatively influences the overall perioperative experience and patient satisfaction.[3]

Several preventive measures have been investigated to minimize airway trauma, including the use of smaller-diameter endotracheal tubes, maintenance of cuff pressure below 20–25 cmH_2O, atraumatic laryngoscopy, adequate lubrication, and careful extubation techniques.[4] In addition, numerous pharmacological interventions such as intracuff lignocaine, topical local anesthetics, ketamine gargles, benzydamine hydrochloride, corticosteroids, and nebulized medications have demonstrated varying degrees of success. However, no single strategy has emerged as the universally accepted standard because their efficacy remains inconsistent across studies and clinical settings.[5-7]

Dexamethasone is a long-acting synthetic glucocorticoid with potent anti-inflammatory activity, estimated to be approximately 25–30 times more potent than hydrocortisone. It suppresses inflammatory responses by inhibiting phospholipase A_2 activity and reducing the production of cytokines, including interleukin-1, interleukin-6, and tumor necrosis factor-α, as well as prostaglandins and leukotrienes.[8] These mechanisms decrease mucosal edema and inflammatory injury associated with airway instrumentation. Clinical studies have shown that dexamethasone administered intravenously, topically, or by nebulization significantly reduces the incidence and severity of POST while also providing additional benefits such as reduced postoperative nausea and vomiting (PONV), lower analgesic requirements, and improved postoperative recovery.[9,10] Nebulized administration offers the advantage of delivering a high local drug concentration directly to the airway mucosa while minimizing systemic exposure.

Magnesium sulfate has also emerged as a promising preventive agent for POST because of its N-methyl-D-aspartate (NMDA) receptor antagonistic, anti-inflammatory, and antinociceptive properties. By inhibiting calcium influx and reducing the release of inflammatory mediators, magnesium sulfate attenuates airway irritation following tracheal intubation. Multiple randomized controlled trials and systematic reviews have demonstrated that topical or nebulized magnesium sulfate significantly decreases both the incidence and severity of POST compared with placebo, with minimal adverse effects.[11-16]

Nebulization is an attractive route for airway drug delivery because aerosolized particles achieve uniform deposition over the oropharyngeal and laryngotracheal mucosa, producing high local drug concentrations precisely at the site of tissue injury. Administration approximately 30 minutes before induction of anesthesia allows sufficient mucosal absorption before airway manipulation, thereby maximizing local anti-inflammatory effects during the period of greatest mechanical trauma while limiting systemic drug exposure.

Although both nebulized dexamethasone and nebulized magnesium sulfate have individually demonstrated efficacy in preventing POST, direct comparative evidence between these two interventions remains limited. Establishing the relative effectiveness of these agents may help identify the optimal prophylactic strategy for routine endotracheal intubation.

Therefore, the present randomized controlled trial was undertaken to compare the effectiveness of preoperative nebulized dexamethasone, nebulized magnesium sulfate, and placebo in reducing the incidence and severity of postoperative sore throat and to

evaluate their effects on perioperative hemodynamic parameters following endotracheal intubation.

MATERIALS AND METHODS

Study Design and Ethical Approval

This prospective, randomized, double-blind, placebo-controlled clinical trial was conducted at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee (Approval No. SGRD/IEC/2024-319). The trial was prospectively registered with the Clinical Trials Registry–India (CTRI No. CTRI/2025/01/079384) before patient recruitment. The study adhered to the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants in their vernacular language before enrolment.

Study Population

Adult patients aged 18–60 years belonging to the American Society of Anesthesiologists (ASA) physical status I or II, with a Modified Mallampati Class I or II airway, scheduled for elective surgery under general anesthesia requiring endotracheal intubation, were screened for eligibility.

Patients were excluded if they had a history of recent upper respiratory tract infection or sore throat, anticipated difficult airway requiring more than two intubation attempts or the use of adjuncts such as a bougie or stylet, previous oral, pharyngeal, or laryngeal surgery or instrumentation, chronic use of corticosteroids, anti-inflammatory drugs, or analgesics, obesity, diabetes mellitus, pregnancy, or any known hypersensitivity to the study medications.

Sample Size Calculation

The sample size was calculated using Epi Info™ software based on the findings of Sharma et al.[8], which reported a postoperative hoarseness incidence of 15.6%. Assuming a study power of 80%, a two-sided significance level of 5%, and a design effect of 1.0, the minimum required sample size was 86 participants. To compensate for an anticipated 5% attrition rate, a total of 90 patients were recruited.

Randomization, Allocation Concealment, and Blinding

Participants were randomly assigned in a 1:1:1 ratio to one of three study groups using a computer-generated randomization sequence prepared by an investigator not involved in patient recruitment or outcome assessment. Allocation concealment was ensured using sequentially numbered, opaque, sealed envelopes that were opened immediately before intervention by an independent anesthesiologist.

The study medications were prepared by personnel who had no further involvement in patient management or data collection. Nebulization solutions were identical in appearance and volume. Patients, the anesthesiologist performing intraoperative management, postoperative outcome assessors, and the statistician remained blinded to group allocation throughout the study.

Study Intervention

Approximately 30 minutes before induction of anesthesia, patients received nebulization using a wall-mounted oxygen source at a flow rate of 10 L/min (50 psi).

Participants were allocated to one of the following groups:

Group A (Dexamethasone group): Dexamethasone 8 mg (2 mL) diluted with 3 mL normal saline (total volume 5 mL).

Group B (Magnesium sulfate group): Magnesium sulfate 50% w/v (2 mL) diluted with 3 mL normal saline (total volume 5 mL).

Group C (Placebo group): Normal saline 5 mL.

Anesthetic Technique

All patients underwent a standardized pre-anesthetic assessment, including clinical examination and relevant laboratory and radiological investigations.

Standard ASA monitoring, including electrocardiography (ECG), non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), and heart rate (HR), was instituted before nebulization. Baseline hemodynamic parameters were recorded before and after nebulization.

Premedication consisted of intravenous glycopyrrolate 0.005 mg/kg and butorphanol 0.02 mg/kg. General anesthesia was induced with intravenous propofol 2 mg/kg, followed by vecuronium 0.15 mg/kg to facilitate endotracheal intubation. Laryngoscopy and intubation were performed approximately 4 minutes after neuromuscular blockade by an experienced anesthesiologist using direct laryngoscopy.

An appropriately sized high-volume, low-pressure cuffed endotracheal tube was used in all patients. Cuff pressure was maintained within the recommended range throughout surgery. Anesthesia was maintained with isoflurane in a mixture of 50% oxygen and 50% nitrous oxide, with intermittent vecuronium supplementation as required.

Intravenous ondansetron 4 mg was administered 20 minutes before extubation for prophylaxis against postoperative nausea and vomiting. At the completion of surgery, neuromuscular blockade was reversed using neostigmine 0.05 mg/kg and glycopyrrolate 0.01 mg/kg intravenously. Gentle oropharyngeal suctioning was performed before extubation, and the

trachea was extubated once patients fulfilled standard extubation criteria.

Following surgery, all patients were transferred to the post-anesthesia care unit (PACU), where supplemental oxygen was administered via face mask at 5 L/min. Postoperative analgesia was standardized with intravenous paracetamol 1 g every 8 hours.

Outcome Measures

The primary outcome was the incidence of postoperative sore throat (POST) within the first 24 hours following extubation.

Secondary outcomes included:

Severity of postoperative sore throat

Incidence and severity of postoperative hoarseness

Incidence and severity of postoperative cough

Changes in perioperative hemodynamic parameters

Postoperative assessments were performed at 0, 4, 8, 12, and 24 hours after extubation by a blinded investigator using direct patient questioning.

The severity of postoperative sore throat, hoarseness, and cough was graded using a validated 4-point ordinal scale:

Grade 0: No symptoms

Grade 1: Mild symptoms

Grade 2: Moderate symptoms

Grade 3: Severe symptoms

Postoperative sore throat was defined as continuous throat pain independent of swallowing, hoarseness as any alteration in voice quality, and cough as sudden forceful expulsion of air from the respiratory tract. Overall POST incidence was defined as the proportion of patients experiencing at least one episode of sore throat during the 24-hour postoperative period. Patients with moderate-to-severe symptoms (Grade ≥2) received aspirin gargles (75 mg) as rescue therapy. Any adverse events or complications were documented throughout the study period.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality using the Shapiro–Wilk test and are presented as mean ± standard deviation (SD). Intergroup comparisons were performed using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test where appropriate. Categorical variables are expressed as frequency and percentage and were compared using the Chi-square test or Fisher's exact test, as appropriate. All statistical tests were two-tailed, and a p-value <0.05 was considered statistically significant.

RESULTS

A total of 90 patients were randomized equally into three groups: nebulized dexamethasone (Group A, n=30), nebulized magnesium sulfate (Group B, n=30), and placebo (Group C, n=30). All participants completed the study and were included in the final analysis (Figure 1& 2).

Baseline demographic and perioperative characteristics, including age, body weight, sex, ASA physical status, duration of laryngoscopy, duration of surgery, and perioperative hemodynamic parameters, were comparable among the three groups (all $p > 0.05$) (Table 1).

The incidence and severity of postoperative sore throat (POST) differed significantly between groups during the early postoperative period (Table 2). Group A consistently demonstrated the lowest incidence of POST, followed by Group B, whereas Group C had the highest incidence. Significant intergroup differences were observed at 0, 4, 8, and 12 hours after extubation ($p < 0.05$), with dexamethasone showing superior efficacy over placebo and better overall performance than magnesium sulfate. By 24 hours, POST had resolved in nearly all patients, with no significant difference among the groups.

A similar trend was observed for postoperative cough (Table 3). The dexamethasone group had the lowest incidence, followed by the magnesium sulfate group, while the placebo group exhibited the highest frequency during the first 12 postoperative hours. These differences were statistically significant at 0, 4, 8, and 12 hours ($p < 0.05$) but were no longer significant at 24 hours.

Postoperative hoarseness was also significantly reduced with nebulized dexamethasone compared with magnesium sulfate and placebo (Table 4). The greatest benefit was observed during the first 12 hours following extubation ($p < 0.05$), with symptoms resolving almost completely in all groups by 24 hours.

Perioperative heart rate, blood pressure, mean arterial pressure, and oxygen saturation remained comparable among the three groups throughout the study (all $p > 0.05$), indicating that neither nebulized dexamethasone nor magnesium sulfate adversely affected hemodynamic stability.

Both interventions were well tolerated. Adverse events were infrequent, mild, and self-limiting, with no serious complications or study withdrawals. Overall, nebulized dexamethasone was more effective than nebulized magnesium sulfate and placebo in reducing postoperative sore throat, cough, and hoarseness during the first 12 hours after endotracheal intubation without affecting perioperative hemodynamic parameters (Table 5).

DISCUSSION

Postoperative sore throat (POST) complicates 21–65% of endotracheal intubations, reducing patient satisfaction despite its self-limiting course. This double-blind, randomized, placebo-controlled trial at Tertiary care centre compared preoperative nebulized dexamethasone 8 mg (Group A), magnesium sulfate 50% w/v 2 mL (Group B), and placebo saline (Group C) in 90 ASA I/II adults aged 18–60 years undergoing elective surgery, demonstrating dexamethasone's superior protection against POST (30% overall incidence vs. 77% B, 100% C; $p < 0.001$), cough, and hoarseness through 12 hours post-extubation, with complete resolution by 24 hours across groups.

Baseline comparability across groups (age 35–36 years, $p=0.962$; weight 70–72 kg, $p=0.498$; vitals $p > 0.05$; surgery duration 88–93 min, $p=0.499$; laryngoscopy 9–9.4 s, $p=0.511$) minimized confounding, consistent with Park et al. [17](age ~51 years) and Sheikh et al.[18] low-risk cohorts. Perioperative hemodynamic stability (HR 75–77 bpm, SBP 114–116 mmHg) further ensured procedural uniformity, attributing outcomes to nebulized prophylaxis targeting laryngopharyngeal inflammation via dexamethasone's glucocorticoid potency versus magnesium's NMDA antagonism.

Dexamethasone's near-elimination of symptoms (POST grade 0: 80–100%; cough/hoarseness: 93–100%) aligns with network meta-analyses ranking nebulized corticosteroids first among prophylactics ($p < 0.001$ vs. placebo), outperforming magnesium and ketamine through mediator suppression (IL-1/6, prostaglandins). Chatterjee et al.[19] similarly found 13% POST incidence with nebulized dexamethasone 8 mg vs. 47% magnesium ($p < 0.05$). Magnesium's intermediate efficacy (60–100% grade 0) matches Sheikh et al.[18] (44% vs. 72% placebo; $p=0.001$) and Ojo et al. [20](17% vs. 45% saline), though inferior to dexamethasone here and in Ashwini et al. [21](58% vs. 28%).

These findings contrast Kunwar et al.[22] dexamethasone-magnesium equivalence ($p > 0.05$), likely due to our three-arm design revealing hierarchy during peak morbidity (4–8 hours), with nebulization's direct mucosal delivery enhancing early efficacy over systemic routes. Minimal adverse events (5.6%; sedation/hypertension A, nausea B) resolved spontaneously, supporting safety superior to IV dexamethasone's glycemic effects.

Nebulized dexamethasone 8 mg emerges as optimal first-line prophylaxis for elective intubation, substantially reducing airway morbidity with minimal systemic impact—magnesium serving as steroid-sparing alternative. Routine preoperative use warrants adoption to enhance recovery quality.

Limitation of the Study

The study was conducted at a single tertiary care center with a relatively small sample size and included only low-risk ASA I–II adults undergoing elective surgery; therefore, the findings may not be generalizable to high-risk patients, emergency surgeries, pediatric or elderly populations, or those with anticipated difficult airways. In addition, postoperative outcomes were assessed only up to 24 hours, precluding evaluation of longer-term airway symptoms.

CONCLUSION

This randomized controlled trial establishes preoperative nebulized dexamethasone as the optimal first-line prophylaxis for preventing postoperative airway complications following endotracheal intubation. Demonstrating superior efficacy over magnesium sulfate and placebo through the critical early recovery period while maintaining hemodynamic stability and excellent tolerability, nebulized dexamethasone addresses a common yet preventable source of postoperative morbidity. These findings support its routine integration into institutional anesthesia protocols for elective surgery, with magnesium sulfate as a valuable steroid-sparing alternative when glucocorticoids are contraindicated. Adoption of this simple, targeted intervention will enhance patient comfort, satisfaction, and recovery quality.

Abbreviations

Abbreviation	Full Form
ASA	American Society of Anesthesiologists
DBP	Diastolic Blood Pressure
ECG	Electrocardiography
ETT	Endotracheal Tube
MAP	Mean Arterial Pressure
POST	Postoperative Sore Throat
PONV	Postoperative Nausea and Vomiting
PACU	Post-Anesthesia Care Unit
NIBP	Non-invasive Blood Pressure

NMDA	N-Methyl-D-Aspartate
RR	Respiratory Rate

Declarations

Ethical Approval and Consent to Participate

The study was approved by the Institutional Ethics Committee of Sri Guru Ram Das Institute of Medical Sciences and Research, Sri Guru Ram Das University of Health Sciences, Amritsar (Approval No. SGRD/IEC/2024-319). The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrolment.

Consent for Publication

Not applicable.

Availability of Data and Materials

The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

Chiteshwar Walia: Conceptualization, methodology, data collection, patient recruitment, investigation, data curation, and preparation of the original manuscript.

Balkaransher Singh: Study supervision, conceptualization, methodology, clinical guidance, interpretation of data, critical revision of the manuscript, and final approval of the submitted version.

Geetanjali & Ruchi Gupta: Clinical supervision, patient management, data interpretation, manuscript review, and critical revision for important intellectual content.

Prabhjot Kaur Gill: Statistical analysis, data validation, formal analysis, interpretation of results, manuscript editing, and final approval of the manuscript.

All authors read and approved the final manuscript.

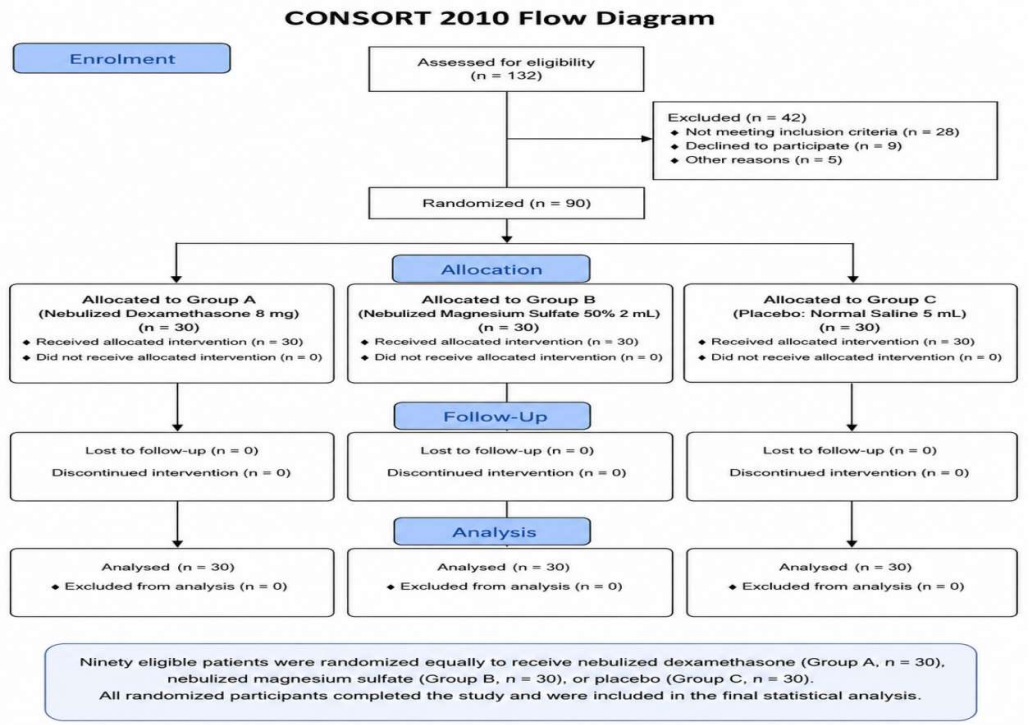

Figure 1. CONSORT 2010 flow diagram illustrating patient recruitment, randomization, allocation, follow-up, and final analysis. Ninety eligible patients were randomized equally to receive nebulized dexamethasone (Group A, n = 30), nebulized magnesium sulfate (Group B, n = 30), or placebo (Group C, n = 30). All randomized participants completed the study and were included in the final statistical analysis.

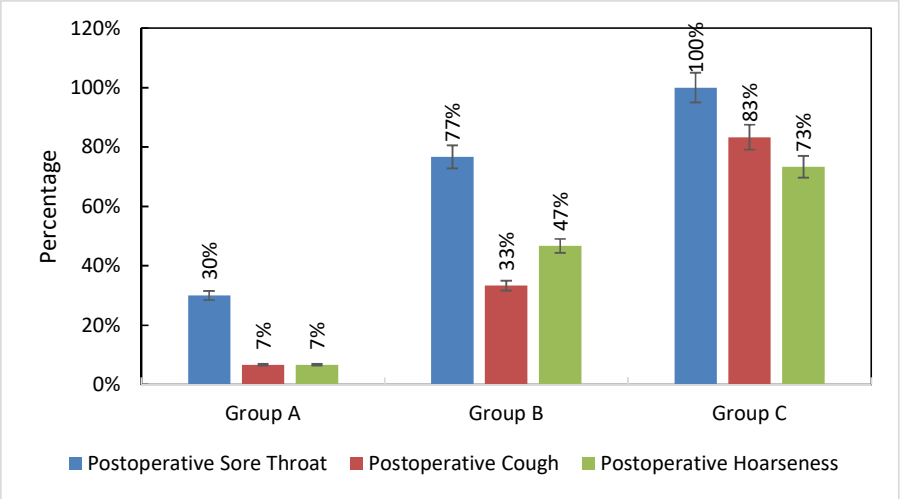

Figure 2: Overall Incidence of Postoperative Sore Throat, Cough, and Hoarseness Following Endotracheal Intubation

Table 1: Baseline Demographic, Clinical, and Perioperative Characteristics of the Study Population

Parameter	Group A	Group B	Group C	F value	Df	p-value
Age (years)	35.57±12.55	35.20±12.06	36.07±11.50	0.039	2,87	0.962
Weight (kg)	72.40±5.76	70.20±7.47	70.87±8.61	0.702	2,87	0.498
Laryngoscopy sec)	9.13±1.22	9.43±0.82	9.30±0.92	0.677	2,87	0.511
Duration of surgery (min)	93.3±16.3	89.3±17.6	88.3±18.0	0.701	2,87	0.499
Female	22 (73.3%)	19 (63.3%)	19 (63.3%)	-	-	-
Male	8 (26.7%)	11 (36.7%)	11 (36.7%)	-	-	-
Grade I	25 (83.3%)	23 (76.7%)	24 (80.0%)	-	-	-
Grade II	5 (16.7%)	7 (23.3%)	6 (20.0%)	-	-	-

Values are presented as mean ± standard deviation (SD) or number (%). Continuous variables were compared using one-way analysis of variance (ANOVA), while categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate. A p-value <0.05 was considered statistically significant.

Table2: Comparison of the Incidence and Severity of Postoperative Sore Throat (POST) at Different Postoperative Time Points

Time point	Score	Group A	Group B	Group C	p-value	A vs B	A vs C	B vs C

0 hr	Score 0	29 (96.7%)	25 (83.3%)	14 (46.7%)	<0.001	0.085	<0.001	0.002
	Score 1	1 (3.3%)	5 (16.7%)	16 (53.3%)				
	Score 2	0 (0%)	0 (0%)	0 (0%)				
4 hr	Score 0	24 (80.0%)	20 (66.7%)	2 (6.7%)	<0.001	0.242	<0.001	<0.001
	Score 1	6 (20.0%)	10 (33.3%)	16 (53.3%)				
	Score 2	0 (0%)	0 (0%)	12 (40.0%)				
8 hr	Score 0	27 (90.0%)	18 (60.0%)	3 (10.0%)	<0.001	<0.001	0.001	<0.001
	Score 1	3 (10.0%)	11 (36.7%)	17 (56.7%)				
	Score 2	0 (0%)	1 (3.3%)	10 (33.3%)				
12 hr	Score 0	30 (100%)	28 (93.3%)	21 (70.0%)	0.006	0.15	0.001	0.06
	Score 1	0 (0%)	2 (6.7%)	8 (26.7%)				
	Score 2	0 (0%)	0 (0%)	1 (3.3%)				
24 hr	Score 0	30 (100%)	30 (100%)	29 (96.7%)	0.667	-	0.313	0.313
	Score 1	0 (0%)	0 (0%)	1 (3.3%)				
	Score 2	0 (0%)	0 (0%)	0 (0%)				

Values are expressed as number (%). Overall intergroup comparisons were performed using the Chi-square test or Fisher's exact test where appropriate. Pairwise comparisons were conducted using Bonferroni-adjusted post hoc analysis. Statistical significance was defined as $p < 0.05$.

Table 3. Comparison of the Incidence and Severity of Postoperative Cough Following Endotracheal Intubation

Timepoint	Score	Group A	Group B	Group C	p-value	A vs B	A vs C	B vs C
0 hr	Score 0	30 (100%)	28 (93.3%)	20 (66.7%)	<0.001	0.006	<0.001	0.009
	Score 1	0 (0%)	2 (6.7%)	10 (33.3%)				
	Score 2	0 (0%)	0 (0%)	0 (0%)				
4 hr	Score 0	29 (96.7%)	28 (93.3%)	18 (60.0%)	0.001	0.553	0.002	0.008
	Score 1	1 (3.3%)	2 (6.7%)	9 (30.0%)				
	Score 2	0 (0%)	0 (0%)	3 (10.0%)				
8 hr	Score 0	29 (96.7%)	23 (76.7%)	17 (56.7%)	0.005	0.071	0.001	0.258
	Score 1	1 (3.3%)	6 (20.0%)	11 (36.7%)				
	Score 2	0 (0%)	1 (3.3%)	2 (6.7%)				
12 hr	Score 0	30 (100%)	30 (100%)	25 (83.3%)	0.010	-	0.065	0.065
	Score 1	0 (0%)	0 (0%)	3 (10.0%)				
	Score 2	0 (0%)	0 (0%)	2 (6.7%)				
24 hr	Score 0	30 (100%)	30 (100%)	29 (96.7%)	0.364	-	0.313	0.313
	Score 1	0 (0%)	0 (0%)	1 (3.3%)				
	Score 2	0 (0%)	0 (0%)	0 (0%)				

Values are expressed as number (%). Overall intergroup comparisons were performed using the Chi-square test or Fisher's exact test where appropriate. Pairwise comparisons were conducted using Bonferroni-adjusted post hoc analysis. Statistical significance was defined as $p < 0.05$.

Table 4. Comparison of the Incidence and Severity of Postoperative Hoarseness Following Endotracheal Intubation

Time point	Score	Group A	Group B	Group C	p-value	A vs B	A vs C	B vs C
0 hr	Score 0	30 (100%)	25 (83.3%)	20 (66.7%)	0.003	0.019	<0.001	0.136
	Score 1	0 (0%)	5 (16.7%)	10 (33.3%)				
	Score 2	0 (0%)	0 (0%)	0 (0%)				
4 hr	Score 0	28 (93.3%)	22 (73.3%)	15 (50.0%)	0.001	0.037	<0.001	0.063
	Score 1	2 (6.7%)	8 (26.7%)	15 (50.0%)				
	Score 2	0 (0%)	0 (0%)	0 (0%)				
8 hr	Score 0	30 (100%)	26 (86.7%)	18 (60.0%)	<0.001	0.038	<0.001	0.049
	Score 1	0 (0%)	4 (13.3%)	10 (33.3%)				

	Score 2	0 (0%)	0 (0%)	2 (6.7%)				
12 hr	Score 0	30 (100%)	29 (96.7%)	14 (46.7%)	<0.001	0.313	<0.001	<0.001
	Score 1	0 (0%)	1 (3.3%)	12 (40.0%)				
	Score 2	0 (0%)	0 (0%)	4 (13.3%)				
24 hr	Score 0	30 (100%)	30 (100%)	29 (96.7%)	0.364	-	0.313	0.313
	Score 1	0 (0%)	0 (0%)	1 (3.3%)				
	Score 2	0 (0%)	0 (0%)	0 (0%)				

Values are expressed as number (%). Overall intergroup comparisons were performed using the Chi-square test or Fisher's exact test where appropriate. Pairwise comparisons were conducted using Bonferroni-adjusted post hoc analysis. Statistical significance was defined as $p < 0.05$.

Table 5. Comparison of Treatment-Related Adverse Events Among the Three Study Groups

Adverse event	Group A (n=30)	Group B (n=30)	Group C (n=30)	p-value*
Excess sedation	0 (0%)	2 (6.7%)	0 (0%)	0.129
Hypertension	3 (10.0%)	0 (0%)	0 (0%)	0.045
Nausea and vomiting	0 (0%)	0 (0%)	2 (6.7%)	0.129

Values are presented as number (%). Comparisons between groups were performed using Fisher's exact test

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