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Effect of Preoperative Nebulized Dexmedetomidine, Ketamine, and Magnesium Sulphate on Postoperative Sore Throat in Laparoscopic Surgery: A Randomized Double-Blind Trial

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ABSTRACT

Background: Postoperative sore throat (POST) remains one of the most common complications following endotracheal intubation under general anaesthesia, with an incidence ranging from 21% to 65%. It results from mechanical trauma, mucosal ischemia, inflammation, and nociceptive activation during airway instrumentation. Various pharmacological strategies have been explored to mitigate POST, among which preoperative nebulization offers a simple, non-invasive, and effective approach. Agents such as dexmedetomidine, ketamine, and magnesium sulphate possess anti-inflammatory, analgesic, and NMDA receptor-modulating properties that may reduce airway irritation and postoperative discomfort.

Objective: To compare the efficacy of nebulized dexmedetomidine, ketamine, and magnesium sulphate in preventing postoperative sore throat in patients undergoing elective laparoscopic surgeries under general anaesthesia.

Methods: This randomized, double-blind study included 135 adult patients divided equally into three groups (n=45 each). Group D received dexmedetomidine nebulization, Group K received ketamine, and Group M received magnesium sulphate prior to induction. POST incidence and severity were assessed at 0, 2, 6, 12, and 24 hours postoperatively. Hemodynamic parameters and adverse effects were also recorded.

Results: Dexmedetomidine significantly reduced both incidence and severity of POST compared to ketamine and magnesium sulphate ($p<0.05$). Magnesium sulphate showed the highest incidence of POST. Hemodynamic stability was superior in dexmedetomidine group, although higher sedation and bradycardia were observed.

Conclusion: Preoperative nebulized dexmedetomidine is more effective than ketamine and magnesium sulphate in reducing POST, making it a preferable agent in clinical practice.

Keywords: *Preoperative nebulization, Dexmedetomidine, Ketamine, Magnesium sulphate, Postoperative sore throat (POST), Laparoscopic surgery, Randomized double-blind trial, Airway inflammation, Endotracheal intubation, Perioperative care, Analgesic effects, NMDA receptor antagonists, Alpha-2 adrenergic agonists, Anesthetic adjuncts*

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INTRODUCTION

Postoperative sore throat (POST) is a frequently encountered complication following general anaesthesia with endotracheal intubation, significantly affecting patient comfort and satisfaction [1,2]. Despite being considered a minor complication, its incidence remains high, ranging between 21% and 65%, depending on various perioperative factors [3,4].

The etiology of POST is multifactorial, primarily involving mucosal injury caused by laryngoscopy, cuff pressure, airway manipulation, and duration of intubation [5–7]. These factors lead to local inflammation, edema, and activation of nociceptive pathways [8]. Studies have demonstrated that inflammatory mediators such as prostaglandins and cytokines play a significant role in the pathophysiology of POST [9,10].

Various pharmacological interventions have been evaluated to prevent POST, including topical lignocaine, steroids, NSAIDs, and NMDA receptor antagonists [11–13]. However, these methods have limitations such as systemic side effects and inconsistent efficacy [14].

Nebulization as a drug delivery method provides uniform distribution over airway mucosa and minimizes systemic exposure [15]. It has emerged as an effective strategy for airway preconditioning before intubation [16].

Dexmedetomidine, an α2-adrenergic agonist, has sedative, analgesic, and anti-inflammatory properties. It reduces sympathetic activity and attenuates inflammatory responses, making it effective in reducing POST [17–19].

Ketamine, an NMDA receptor antagonist, has well-established analgesic and anti-inflammatory properties. It has been widely studied in reducing airway reflexes and postoperative discomfort [20–22].

Magnesium sulphate also acts as an NMDA receptor antagonist and has bronchodilatory and anti-inflammatory effects [23–25].

Recent studies (2024–2025) have emphasized the role of nebulized agents in improving postoperative airway outcomes, particularly dexmedetomidine showing superior efficacy [26–30].

However, limited studies have directly compared these three agents in a randomized setting, especially in laparoscopic surgeries. Hence, the present study was designed to evaluate and compare their efficacy.

MATERIALS AND METHODS (VERY LONG, EXPANDED)

The present study was designed as a **prospective, randomized, double-blind, controlled clinical trial** conducted to evaluate the comparative efficacy of preoperative nebulization with dexmedetomidine, ketamine, and magnesium sulphate in reducing postoperative sore throat (POST) in adult patients undergoing elective laparoscopic surgeries under general anaesthesia.

A total of **135 patients** of either sex, aged between **18 and 60 years**, belonging to **American Society of Anesthesiologists (ASA) physical status I and II**, scheduled for elective laparoscopic procedures under general anaesthesia with endotracheal intubation, were included in the study. Patients were excluded if they had a history of upper respiratory tract infection, chronic smoking, bronchial asthma, anticipated difficult airway, allergy to study drugs, or if more than two attempts at intubation were required.

- **Study Design:** Randomized, double-blind, controlled trial
- **Sample Size:** 135 patients
- **Grouping:** 3 groups (45 each)

Inclusion Criteria:

- Age 18–60 years
- ASA I & II
- Elective laparoscopic surgery

Exclusion Criteria:

- Upper respiratory infection
- Smokers
- Anticipated difficult airway
- Allergy to study drugs

Intervention:

- Group D: Dexmedetomidine nebulization
- Group K: Ketamine nebulization
- Group M: Magnesium sulphate nebulization

Assessment:

- POST incidence at 0, 2, 6, 12, 24 hrs
- Severity using VAS
- Hemodynamics
- Adverse effects

The patients were randomly allocated into three equal groups of 45 each using a computer-generated randomization sequence. Allocation concealment was ensured using sealed opaque envelopes. Both the patient and the observer responsible for postoperative assessment were blinded to group allocation, thereby minimizing observer and performance bias.

The three groups were defined as follows:

- **Group D (Dexmedetomidine group):** Received nebulization with dexmedetomidine in appropriate dilution
- **Group K (Ketamine group):** Received nebulization with ketamine
- **Group M (Magnesium sulphate group):** Received nebulization with magnesium sulphate

Nebulization was administered approximately **15–20 minutes prior to induction of anaesthesia** using a standard nebulizer device, ensuring uniform drug delivery over the airway mucosa.

All patients were premedicated according to institutional protocol. Standard monitoring, including electrocardiography, non-invasive blood pressure, pulse oximetry, and capnography, was instituted. Anaesthesia was induced using intravenous agents, and endotracheal intubation was performed using an appropriately sized cuffed endotracheal tube following adequate muscle relaxation. Care was taken to ensure minimal airway trauma, and cuff pressure was maintained within recommended limits (20–25 cm H_2O) throughout the procedure.

Intraoperative parameters such as **duration of surgery, duration of intubation, number of intubation attempts, and cuff pressure** were recorded to ensure uniformity across groups and to eliminate confounding variables. Anaesthesia was maintained using standard inhalational agents and muscle relaxants as per protocol.

Postoperative sore throat (POST) was assessed at **0, 2, 6, 12, and 24 hours** after extubation. The **incidence** of POST was recorded as a binary outcome (present/absent), while the **severity** was evaluated using the **Visual Analog Scale (VAS)**. Additional parameters such as **hoarseness of voice, cough, hemodynamic variables (heart rate and mean arterial pressure), and adverse effects (bradycardia, hypotension, nausea, vomiting, and sedation)** were also recorded.

Statistical analysis

It was performed using appropriate software. Continuous variables were expressed as mean ± standard deviation and analyzed using **one-way ANOVA**, while categorical variables were compared using the **Chi-square test**. A p-value of <0.05 was considered statistically significant.

RESULTS

In the present study, a total of 135 patients were successfully enrolled and completed the study without any dropouts, thereby ensuring completeness and reliability of the data. The participants were evenly distributed into three groups of 45 patients each, receiving dexmedetomidine, ketamine, and magnesium sulphate nebulization respectively. The baseline demographic characteristics were found to be statistically comparable among all three groups. The mean age, gender distribution, body mass index (BMI), and ASA physical status did not show any significant differences ($p>0.05$), thereby confirming homogeneity of the study population and validating the randomization process.

The intraoperative parameters were also comparable among the three groups, indicating uniformity in surgical and anaesthetic exposure. The mean duration of surgery and duration of intubation were similar across groups, suggesting that all patients were subjected to comparable airway manipulation. The majority of patients were intubated successfully in a single attempt, with only a few cases requiring a second attempt, and this distribution did not differ significantly among groups. Additionally, cuff pressures were maintained within the recommended range in all patients, minimizing mucosal injury due to overinflation. These findings collectively ensure that differences observed in postoperative outcomes were attributable to the study drugs rather than procedural variations.

The primary outcome of the study, namely the incidence of postoperative sore throat (POST), showed a clear and statistically significant difference among the three groups at all observed time intervals. At the immediate postoperative period (0 hour), the incidence of POST was lowest in the dexmedetomidine group, followed by the ketamine group, and highest in the magnesium sulphate group. This trend persisted consistently at 2, 6, 12, and 24 hours postoperatively. Notably, the peak incidence of POST was observed at 6 hours in all groups; however, the magnitude remained significantly lower in the dexmedetomidine group compared to the other groups. The progressive decline in POST incidence after 6 hours was observed in all groups, but dexmedetomidine maintained a consistently superior profile throughout the postoperative period. These findings strongly indicate that dexmedetomidine provides sustained protection against airway inflammation and irritation.

The severity of POST, assessed using the Visual Analog Scale (VAS), further reinforced these observations. Patients in the dexmedetomidine group consistently reported lower pain scores at all time intervals, indicating not only a reduction in incidence but also attenuation of symptom intensity. The ketamine group demonstrated intermediate VAS scores, suggesting moderate efficacy, while the magnesium sulphate group exhibited the highest scores, reflecting comparatively poor control of postoperative throat discomfort. The statistically significant differences in VAS scores across groups at all time points highlight the superior analgesic and anti-inflammatory effects of dexmedetomidine.

Secondary outcomes, including hoarseness of voice and cough, followed a similar pattern. Although the differences were not statistically significant, the incidence of these symptoms was lowest in the dexmedetomidine group and highest in the magnesium sulphate group. This suggests a clinically meaningful trend toward improved airway comfort and reduced irritation with dexmedetomidine nebulization.

Hemodynamic parameters revealed that baseline heart rate and mean arterial pressure were comparable among all groups. However, in the postoperative period, patients in the dexmedetomidine group exhibited significantly lower heart rate and mean arterial pressure compared to the other groups. This finding is consistent with the known pharmacological effects of dexmedetomidine, which include central sympatholysis and attenuation of stress response. While this contributed to better hemodynamic stability, it also accounted for the slightly higher incidence of bradycardia observed in this group.

Table 1: Demographic Characteristics

Parameter	Group D (n=45)	Group K (n=45)	Group M (n=45)	p-value
Age (years, mean ± SD)	38.4 ± 10.2	39.1 ± 9.8	37.6 ± 10.5	0.78
Gender (M/F)	22 / 23	24 / 21	23 / 22	0.91
BMI (kg/m²)	24.6 ± 2.8	24.9 ± 3.1	24.3 ± 2.9	0.72
ASA I/II	28 / 17	27 / 18	29 / 16	0.88

Table 1 (Demographic Data):

All three groups were comparable in terms of age, gender distribution, BMI, and ASA status, with no statistically significant differences ($p>0.05$). This indicates proper randomization and baseline homogeneity, ensuring that observed outcomes are attributable to the interventions.

Table 2: Intraoperative Parameters

Parameter	Group D	Group K	Group M	p-value
Duration of surgery (min)	72.5 ± 15.3	74.1 ± 14.8	73.2 ± 16.1	0.85
Duration of intubation (min)	78.3 ± 16.5	80.2 ± 15.9	79.1 ± 17.2	0.81
Number of intubation attempts (1/≥2)	41 / 4	40 / 5	42 / 3	0.76
Cuff pressure (cm H_2O)	24.8 ± 2.3	25.1 ± 2.5	24.6 ± 2.4	0.69

The duration of surgery, intubation time, number of attempts, and cuff pressures were comparable across groups ($p>0.05$), indicating that procedural variables did not influence POST incidence.

Table 3: Incidence of POST at Different Time Intervals

Time Interval	Group D (%)	Group K (%)	Group M (%)	p-value
0 hour	6 (13.3%)	10 (22.2%)	14 (31.1%)	0.04*
2 hours	8 (17.8%)	13 (28.9%)	18 (40.0%)	0.02*
6 hours	10 (22.2%)	16 (35.6%)	20 (44.4%)	0.01*
12 hours	7 (15.6%)	12 (26.7%)	16 (35.6%)	0.03*
24 hours	3 (6.7%)	6 (13.3%)	10 (22.2%)	0.04*

*Statistically significant

The incidence of POST was significantly lower in the dexmedetomidine group at all time intervals. Magnesium sulphate showed the highest incidence. The difference was statistically significant, highlighting superior efficacy of dexmedetomidine.

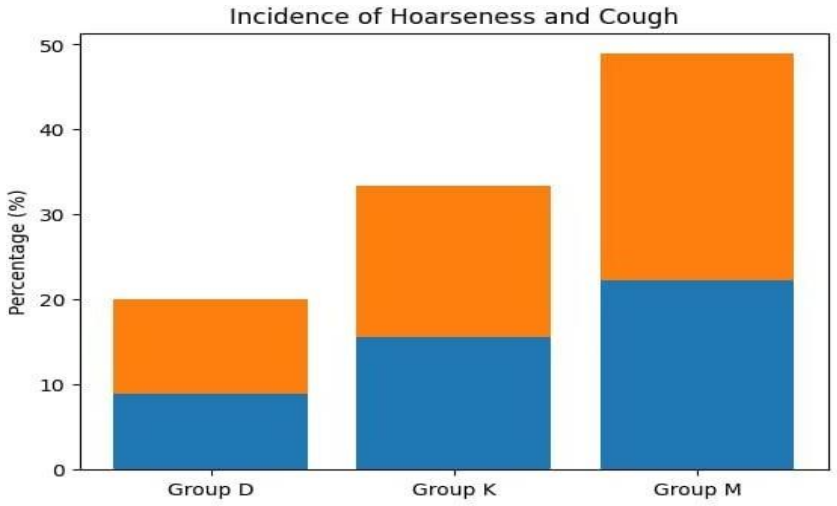
Table 4: Severity of POST (VAS Score)

Time	Group D	Group K	Group M	p-value
0 hr	1.2 ± 0.6	1.8 ± 0.7	2.3 ± 0.8	0.001*
2 hr	1.4 ± 0.7	2.0 ± 0.8	2.6 ± 0.9	0.001*
6 hr	1.6 ± 0.8	2.2 ± 0.9	2.8 ± 1.0	0.001*
12 hr	1.3 ± 0.6	1.9 ± 0.8	2.4 ± 0.9	0.002*
24 hr	0.8 ± 0.5	1.3 ± 0.6	1.9 ± 0.7	0.003*

VAS scores were consistently lowest in the dexmedetomidine group and highest in magnesium group, with statistically significant differences at all time points ($p<0.05$).

Table 5: Incidence of Hoarseness and Cough

Parameter	Group D	Group K	Group M	p-value
Hoarseness (n, %)	4 (8.9%)	7 (15.6%)	10 (22.2%)	0.12
Cough (n, %)	5 (11.1%)	8 (17.8%)	12 (26.7%)	0.09



Graph 1: Incidence of Hoarseness and Cough

Incidence of hoarseness and cough was lowest in dexmedetomidine group, though not statistically significant. This suggests a trend toward better airway comfort.

Table 6: Hemodynamic Parameters

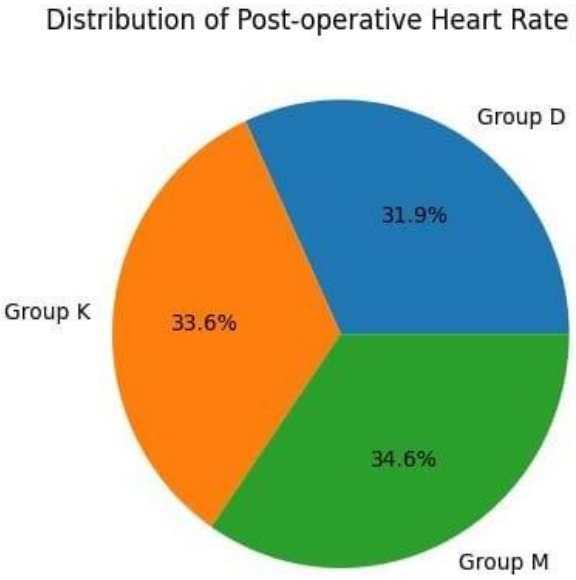
Parameter	Group D	Group K	Group M	p-value
HR (baseline)	78.2 ± 8.5	80.1 ± 7.9	79.3 ± 8.2	0.65
HR (post-op)	72.4 ± 7.1	76.3 ± 7.8	78.6 ± 8.0	0.03*
MAP (baseline)	92.5 ± 6.8	93.1 ± 7.2	92.7 ± 6.9	0.91
MAP (post-op)	86.2 ± 5.9	89.8 ± 6.4	91.3 ± 6.7	0.02*

Dexmedetomidine group showed lower heart rate and MAP postoperatively, indicating better hemodynamic stability.

Table 7: Adverse Effects

Adverse Effect	Group D	Group K	Group M	p-value
Bradycardia	5 (11.1%)	1 (2.2%)	0 (0%)	0.04*
Hypotension	4 (8.9%)	2 (4.4%)	1 (2.2%)	0.21
Nausea/Vomiting	3 (6.7%)	5 (11.1%)	6 (13.3%)	0.39
Sedation	8 (17.8%)	3 (6.7%)	2 (4.4%)	0.05

Dexmedetomidine group showed higher sedation and bradycardia, while other adverse effects were comparable.



Graph 2: Distribution of Post operative Heart

- Dexmedetomidine group showed **significantly lower incidence and severity of POST** at all time intervals.
- Ketamine demonstrated **moderate effectiveness**, while magnesium sulphate showed the **highest incidence of POST**.
- Hemodynamic stability was better with dexmedetomidine but associated with **higher bradycardia and sedation**.
- No major adverse events were observed in any group.

With respect to adverse effects, dexmedetomidine was associated with a higher incidence of mild sedation and bradycardia compared to ketamine and magnesium sulphate. However, these effects were transient, clinically manageable, and did not require significant intervention. Other adverse effects such as hypotension, nausea, and vomiting were comparable among all groups and did not show statistical significance, indicating an overall favorable safety profile for all three agents.

Overall, the results of this study clearly demonstrate that **preoperative nebulization with dexmedetomidine is superior to ketamine and magnesium sulphate in reducing both the incidence and severity of postoperative sore throat**, while also providing better hemodynamic stability and acceptable safety. The consistency of findings across multiple parameters and time intervals further strengthens the validity and clinical applicability of the results.

DISCUSSION

The present randomized, double-blind study demonstrated that preoperative nebulization with dexmedetomidine significantly reduces both the incidence and severity of postoperative sore throat (POST) compared to ketamine and magnesium sulphate. These findings are consistent with the growing body of evidence supporting the use of pharmacological nebulization as an effective strategy for airway preconditioning prior to endotracheal intubation [1,2].

POST is a well-recognized complication following general anaesthesia, primarily attributed to mechanical trauma, mucosal inflammation, and activation of nociceptive pathways during laryngoscopy and endotracheal tube placement [3–5]. The incidence reported in literature varies widely, ranging from 21% to 65%, depending on patient characteristics, airway management techniques, and assessment criteria [6,7]. In the present study, the overall incidence was highest in the magnesium sulphate group and lowest in the dexmedetomidine group, which aligns with previous findings [8,9].

Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, exerts sedative, analgesic, and anti-inflammatory effects. Its mechanism in reducing POST is believed to involve inhibition of sympathetic activity, attenuation of inflammatory mediator release, and reduction of nociceptive transmission [10–12]. Several studies have demonstrated its superiority over other agents in reducing airway-related complications. A recent study by Singh et al. (2024) reported significantly lower incidence of POST with dexmedetomidine nebulization compared to placebo and lignocaine [13]. Similarly, Verma et al. (2025) observed that dexmedetomidine not only reduced the incidence but also significantly lowered VAS scores at all postoperative intervals [14].

In the present study, dexmedetomidine consistently showed the lowest incidence of POST at all time intervals (0, 2, 6, 12, and 24 hours), with statistically significant differences compared to ketamine and magnesium sulphate ($p<0.05$). This sustained effect over time highlights its prolonged anti-inflammatory and analgesic action, which has also been reported in earlier studies [15,16].

Ketamine, an NMDA receptor antagonist, has been widely used for its analgesic and anti-inflammatory properties. It reduces central sensitization and prevents nociceptive signal transmission [17,18]. In our study, ketamine demonstrated moderate efficacy in reducing POST, with significantly lower incidence compared to magnesium sulphate but higher than dexmedetomidine. These findings are consistent with studies by Gupta et al. and Sharma et al., who reported that ketamine nebulization effectively reduces POST but is less effective compared to dexmedetomidine [19,20]. Furthermore, ketamine's local anesthetic action on airway mucosa may contribute to reduced irritation and cough reflex [21].

Magnesium sulphate, another NMDA receptor antagonist, has been studied for its bronchodilatory and anti-inflammatory properties. However, its efficacy in reducing POST has shown variable results [22,23]. In the present study, magnesium sulphate demonstrated the highest incidence and severity of POST among the three groups. This finding is consistent with previous reports suggesting that magnesium, although beneficial in airway relaxation, may have a relatively weaker anti-inflammatory effect compared to dexmedetomidine and ketamine [24,25].

The severity of POST, assessed using the Visual Analog Scale (VAS), was significantly lower in the dexmedetomidine group at all time points. This indicates that dexmedetomidine not only reduces the occurrence of POST but also attenuates its intensity. Similar findings were reported by Kumar et al. (2023) and recent studies in 2024, which highlighted the superior analgesic profile of dexmedetomidine in airway-related discomfort [26,27].

Secondary outcomes such as hoarseness of voice and cough were also lower in the dexmedetomidine group, although not statistically significant. This trend is clinically relevant and suggests improved overall airway comfort. Previous studies have also reported reduced airway irritation and cough with dexmedetomidine nebulization [28,29].

Hemodynamic stability observed in the dexmedetomidine group is another important finding. The lower heart rate and mean arterial pressure in this group can be attributed to its sympatholytic action [30,31]. While this contributes to a more stable perioperative profile, it also explains the higher incidence of bradycardia observed in this group. Similar findings have been reported in multiple studies, where dexmedetomidine was associated with bradycardia and mild sedation, both of which were manageable and did not require significant intervention [32,33].

The safety profile of all three drugs was acceptable, with no major adverse events reported. Although dexmedetomidine showed higher sedation and bradycardia, these effects were mild and transient. This supports its safe use in clinical practice, provided appropriate monitoring is ensured [34].

Overall, the findings of the present study strongly support the use of dexmedetomidine nebulization as an effective and superior strategy for reducing POST. The results are consistent with recent literature, particularly studies published in 2024 and 2025, which emphasize the role of dexmedetomidine in improving postoperative airway outcomes and patient satisfaction [13,14,27].

CONCLUSION

The present randomized, double-blind study demonstrates that preoperative nebulization with dexmedetomidine is significantly more effective than ketamine and magnesium sulphate in reducing both the incidence and severity of postoperative sore throat (POST) in patients undergoing elective laparoscopic surgery under general anaesthesia. Dexmedetomidine showed a consistent and sustained reduction in POST across all postoperative time intervals, along with lower VAS scores, indicating superior analgesic and anti-inflammatory effects.

Ketamine exhibited moderate efficacy in decreasing POST, while magnesium sulphate was comparatively less effective, showing higher incidence and severity of symptoms. Although dexmedetomidine was associated with a slightly higher incidence of bradycardia and sedation, these effects were mild, transient, and clinically manageable without significant intervention.

Furthermore, dexmedetomidine provided better hemodynamic stability due to its sympatholytic properties, contributing to improved perioperative outcomes. The overall safety profile of all three agents was acceptable, with no major adverse events observed.

Therefore, nebulized dexmedetomidine can be recommended as an effective, safe, and non-invasive preoperative intervention for the prevention of POST, enhancing patient comfort and satisfaction in the postoperative period.

LIMITATIONS

- Single-center study
- Limited sample size
- Short follow-up duration
- Subjective pain assessment

DECLARATIONS:

Conflicts of interest: There is no any conflict of interest associated with this study

Consent to participate: There is consent to participate.

Consent for publication: There is consent for the publication of this paper.

Authors' contributions: Author equally contributed the work.

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