Randomised Controlled Trial

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Volume-based subglottic secretion drainage: a randomized controlled trial

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Background: This study proposed to explore individual management mode for patients with subglottic secretion drainage.
Methods: Randomly chosen within the hospital ICU 68 patients from 7 April to 15 June 2023, all the patients randomly assigned to the control group or observation group, and control group adopts the model of intermittent drainage management, observation group based on the volume of subglottic secretion in patients with individualized management, and then analysis the two groups of patients clinical trial results.
Results: The clinical trial results showed that there were statistically significant differences ($P < 0.05$) between the control group and the observation group in the incidence of tube blockage events (11 vs. 2), average diurnal pumping frequency (9 vs. 7, 5 vs. 4) between the two groups and the patient satisfaction scores (6 vs. 7), In the partial mucosa injure (22 vs 19) and VAP (5 vs. 1) there were no statistically significant difference ($P > 0.05$). Although there was no statistically significant difference ($P > 0.05$) in the average aspiration volume (12.68 ± 3.41 vs. 12.19 ± 2.68, 8 vs. 8) between the two groups, but the management mode of the observation group indicated that based on patient secretion volume was more consistent with the characteristics of the body's diurnal metabolic differences, because there was a big difference between the average total amount of daytime and nighttime suction between the two groups.
Conclusion: Individualized management based on the volume of subglottic secretions produced by patients can further optimize the airway management of patients and reduce the risk of adverse events of subglottic secretions aspiration.

Keywords: clinical trial, ICU, individual management mode, subglottic secretion drainage, VAP

Introduction

In recent years, the incidence of severe respiratory diseases has been on the rise. To improve the pulmonary function of patients, the establishment of an artificial airway is a necessary treatment measure[1]. The establishment of an artificial airway can not only improve the ventilation function of patients, but also compromise the normal anatomy and defense mechanisms of the respiratory tract. The continuous irritation of the upper respiratory tract caused by the insertion of the artificial tube can lead to increased secretion accumulation between the glottis and the trachea. These secretions may flow into the lungs through the side of the endotracheal tube via inhalation or aspiration, thereby directly increasing the risk of bacterial infection in patients[2]. According to the study[3], subglottic secretions are a direct contributor to the development of ventilator-associated pneumonia (VAP) in patients. VAP is defined as inflammation of the lungs in a patient that occurs after 48 h of mechanical ventilation therapy or within 48 h of wean off ventilator, which is a common and serious

HIGHLIGHTS

For the management of subglottic secretions in mechanically ventilated patients, there are mainly intermittent subglottic secretion aspiration and continuous subglottic secretion aspiration, and both modes have their own advantages and disadvantages. For all types of critically ill patients, different diseases, different ages, different physical conditions and other factors will directly lead to significant differences in the amount of subglottic secretion production. At the same time, because of the significant difference between daytime and nighttime treatment measures for critically ill patients, there is also a direct difference in the amount of subglottic secretion produced by the patient during the day and night. Based on the current research situation at home and abroad, combining the physiological characteristics of patients and the treatment characteristics of the intensive care unit, this study formulated an individualized intervention strategy based on the amount of patients' subvocal secretions, and the results of clinical practice show that this strategy has a good control effect on the patients' subvocal secretions.

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complication of artificial airway therapy with high morbidity and mortality rates. Effective management of subglottic secretions is an important measure for preventing VAP[4]. Subglottic suction is a method of draining secretions from above the balloon by applying a balloon cannula with a subglottic suction device, thus preventing secretions from entering the lungs. Although continuous subglottic drainage can ensure adequate drainage, it is associated with adverse reactions such as mucosal bleeding. Intermittent subglottic drainage can prevent mucosal bleeding, but it may not guarantee adequate drainage[5]. For patients with an artificial airway, frequent suctioning without indication can cause local tissue hypoxia and decrease in blood oxygen levels, even in the absence of any apparent respiratory distress[6]. Therefore, Effective management of subglottic secretions is of great clinical significance for patients with an artificial airway. Currently, two management modes for subglottic secretions are available: continuous subglottic drainage and intermittent subglottic drainage, each with its own advantages and disadvantages. In this study, we aim to explore an accurate management model based on individual patient factors by weighing the advantages and disadvantages of each mode, and to analyze its clinical application and efficacy.

Study subjects

From 25 March to 6 April 2023, we selected 16 patients from our hospital who met the inclusion and exclusion criteria for the clinical pre-test. The incidence of adverse events such as subglottic suction and blockage, mucosal injury, and other adverse events were used as outcome indicators. The results showed that the incidence rate was 75% in the control group and 21% in the observation group, with a significance level of 0.05 and a β value of 0.02. Sample size calculation using the statistical software PASS11.0 indicated a total of 62 patients were required, with an additional 10% added to account for potential missing data, resulting in a final sample size of 68 cases. Due to insufficient sample size during the same period, we conducted a non-synchronous randomized controlled study. From 7 April to 15 June 2023, we sampled mechanically ventilated patients admitted to the intensive care unit of a tertiary hospital. Patients who met the inclusion and exclusion criteria during each period were uniformly and randomly assigned to either the control group or the observation group at a ratio of 1:1 by random number ranking table method. Before the study began, all patients and/or their families were provided with an explanation and education about the study, and their right to informed consent was obtained. This study has been approved by the Ethics Committee of our Hospital (approval number: 2022-035). The inclusion criteria were as follows: patients aged 18 years or older, mechanical ventilation time greater than or equal to 48 h, and use of a subglottic suction endotracheal tube. Patients or their family members who were willing to participate in the study were also included. The exclusion criteria were the presence of a pulmonary infection, severe electrolyte disturbance, severe arrhythmias, or hemodynamic instability. The shedding standards included transfer to another department or hospital, or death during treatment.

Methods

For the purpose of this study, a research team was established, including three directors of ICU, two head nurses, two chief physicians of respiratory medicine, several nursing graduate students and clinical nurses. Three directors and two head nurses have more than 10 years of critical work experience, and can timely and effectively respond to emergencies in the process of intervention. they mainly responsible for disease management of patients and quality control of the intervention period. The two chief physicians of respiratory medicine have rich clinical management experience in the treatment of mechanical ventilation, they can optimize and improve the intervention plan for this study based on the field of respiratory treatment. Several nursing graduate students and nurses have a relatively standardized nursing operation process, mainly responsible for the implementation of intervention measures and the collection of the experimental data.

The reporting of this study conforms to the CONSORT statements. In this study, only the management mode of subglottic secretions was different between the two groups, and the other nursing measures were consistent. All patients in the two groups received routine care with cluster nursing measures to prevent VAP, including maintaining the air sac pressure at 25–30 cmH_2O and maintaining the detection every 4 h. The vacuum aspiration pressure values under glottis were maintained at 100–150 mmHg, and the aspiration time was less than 15 s. Hand hygiene is strictly enforced by all personnel during operations. During the intervention, the nursing staff paid close attention to the patient's respiration, blood oxygen saturation as well as other vital signs, and accurately recorded the colour, character and quantity of the patient's secretions.

The control group was administered with intermittent suction mode, and the subglottic secretions were drained for 4 h as intermittent suction. At the same time, in order to improve the safety of treatment for patients, suction on-demand[7] should be supplemented during the management period, that is to say, in the course of treatment, if the patients vomit, active signal suction and other events, regardless of whether the interval time of suction is reached, the patients will be pumped with secretions.

The observation group formulated a precise management strategy based on the secretion of patients, and the management strategy was preliminaries formulated on the basis of existing research, such as Ciampoli[8] and Lacherade[9], and then invited 8 experts in critical medicine and respiratory critical care fields from our province to hold a meeting to discuss the scientificity and rationality of the preliminary plan. After the meeting, the judgment basis and familiarity of the experts were statistically analyzed, and the authority coefficient of the experts in this study was calculated to be 0.75, which indicated that the experts had high authority and credibility. The research team conducted a full discussion based on the opinions of the participating experts, and finally decided that the observation group should set the attraction frequency based on the individual diurnal secretion per unit time and set the intervention threshold as 3mL,That is, according to the calculation of the total amount of day and night secretions of the patients on the previous day, the average production of subglottic secretions per hour was obtained, the frequency and interval of attraction were set according to the individual secretion of the patients. At the same time, in order to improve the safety of treatment for patients, suction on-demand[7] should be supplemented during the management period. That is, if the patient has vomiting and other events in the course of treatment, patients will be given secretion aspiration whether the critical value of intervention is reached or not. The intervention pattern of the observation group is shown in Figure 1.

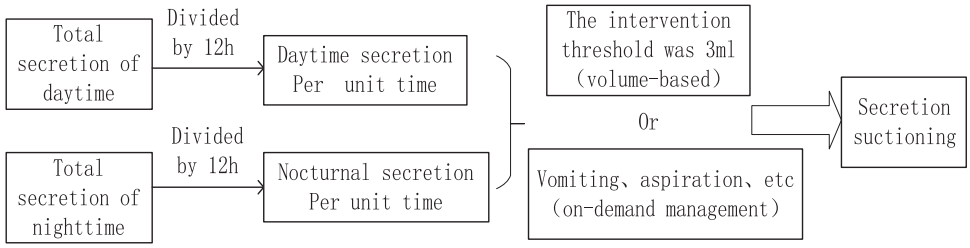

Figure 1. Volume-based and On-demand management.

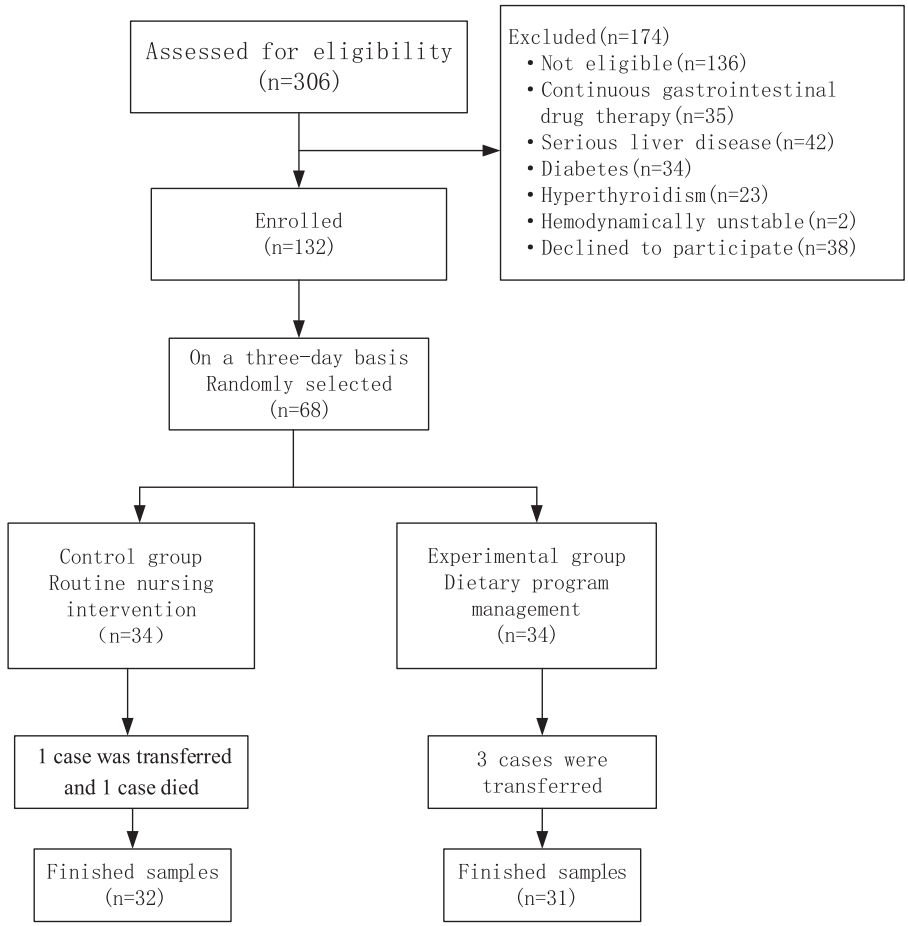

Figure 2. Study CONSORT diagram.

Data collection

The research team discussed and formulated the following observation indexes based on the reported status of subglottic secretion drainage: (1)Tube jam rate: The judgment criterion was to connect the subglottic suction sleeve and the negative pressure suction device. After adjusting the negative pressure to 100–150 mmHg, no secretions were extracted, but the residual secretions could be seen on the inner wall of the subglottic suction catheter, which was considered as tube plugging. (2) Mucosal injury: The condition of mucosal injury was jointly evaluated by two directors of the Department of Severe Diseases using fiber-optic bronchoscope before extubation. The assessment criteria for mucosal injury were determined according to the Level 5 assessment criteria reported by Seguin[10], which were asymptomatic, local erythema, oedema, ulcer and necrosis, respectively. (3) Incidence of VAP: The director of intensive care was evaluated and judged by referring to the Update and Interpretation of Guidelines for the Diagnosis and Treatment of Acquired Pneumonia and Ventilators Associated Pneumonia[11]. (4) The average diurnal aspiration volume and frequency: that is, the average diurnal aspiration volume and frequency of subglottic secretions in the two groups were recorded within 5 days of mechanical ventilation treatment, and the nurses on duty were recorded according to the actual conditions of the patients. (5) Patient satisfaction: At the end of the mechanical ventilation

therapy (patients were awake), a self-made satisfaction rating scale was used to investigate and record the result of patients attitudes towards medical environment, health education, nursing operation, nursing attitude and mental nursing.

Statistical analysis

SPSS23.0 statistical software was used for statistical analysis of the relevant data, and the $R \times C$ χ^2 test was used for the gender count data of patients. If the measures such as Apache II scores and patient satisfaction scores met the conditions of normal distribution and χ^2, they were statistically analyzed using the independent samples *t*-test. If they were not met then they were statistically analyzed using the Mann–Whitney U test. All rank information was statistically analyzed using the rank sum test. The test level $a = 0.05$, and *P* less than 0.05 indicated that the difference was statistically significant.

Results

7 April to 15 June 2023, we screened 306 patients. There are 132 eligible patients consented to participated. On a 3-day basis, we randomly selected 68 eligible patients from 132 patients for the clinical trial. 68 patients were randomly divided into control group and observation group. During the period of this study, one case was transferred to the other department and one case died in the control group. In the observation group, three cases were transferred to another department (Fig. 2). A total of 63 cases were completed in the study. The 63 patients Characteristics did not differ significantly among the two groups at baseline (Table 1).

After 5 days of clinical intervention, the study results showed that :(1) there was statistically significant difference ($P < 0.05$) in the occurrence of tube jam rate between the control group (34%) and the observation group (6.45%), but there was no statistically significant difference ($P > 0.05$)in the occurrence of VAP; (2) The assessment results of mucosal injury in the two groups were mainly asymptomatic, erythema and oedema, and the differences were not statistically significant ($P > 0.05$), but the overall situation of the observation group was slightly better than control group.(3) There was no significant difference ($P > 0.05$)in the diurnal average aspiration volume between the two groups , while there was significant difference in intra-group aspiration volume ($P < 0.001$). The average aspiration volume in daytime was higher than nighttime in the two groups. At the same time, there were significant differences ($P < 0.001$) in the mean aspiration frequency between the two groups during the day and night, According to clinical practice results, the mean aspiration frequency in the daytime was higher than night.(4) The results of the satisfaction survey of patients in the two groups showed that there were statistically significant ($P < 0.05$) differences in operation and attitude survey between the two groups under the different management modes (Table 2).

Discussion

There are mainly two modes of management for subglottic secretions in patients with mechanical ventilation: continuous drainage and intermittent drainage. Both of these modes are based on time, and their clinical application effects have their own advantages and disadvantages. Although continuous suction can effectively prevent the retention of secretions above the endotracheal tube cuff and ensure sufficient drainage, it is also associated with the risk of dry respiratory mucosa and bleeding[12]. By reducing the suction frequency, intermittent suction can allow the mucous membrane above the endotracheal tube cuff to rest, reduce the variation range of airway temperature and humidity, and effectively alleviate the damage of negative pressure on the mucous membrane. However, it cannot guarantee the effectiveness of suction, which may lead to the obstruction of the suction tube and other conditions[13]. Therefore, how to prevent the occurrence of adverse events such as tube blockage and mucosal injury under the condition of sufficient attraction needs to be further studied and discussed.

Table 1

Patient characteristics at baseline.

Variable	Time-based and on-demand management ($n = 32$)	Volume-based and on-demand management ($n = 31$)	$t/x^2/z$	*P*
Sex			0.450	0.503[a]
Male, *N* (%)	18 (56)	20 (64)	—	—
Female, *N* (%)	14 (44)	11 (35)	—	—
Age			0.973	0.652[a]
Between 18 and 39, *N* (%)	5 (15)	7 (22)	—	—
Between 40 and 59, *N* (%)	15 (47)	11 (35)	—	—
More than 60, *N* (%)	12 (38)	13 (41)	—	—
APACHE II score, mean (SD)	13.75 (3.58)	14.93 (3.44)	1.338	0.186[b]
BMI, mean (SD)	21.03 (2.50)	22.22 (2.70)	1.819	0.074[b]
ICU length of stay, M (Q_{25},Q_{75})	6 (5,7)	6 (5,7)	0.876	0.381[c]
Reasonintubated			0.973	0.914[a]
Respiratory failure, *N* (%)	9 (28)	11 (35)	—	—
COPD, *N* (%)	10 (32)	7 (22)	—	—
Cerebral trauma, *N* (%)	8 (25)	9 (29)	—	—
Cerebral infarction, *N* (%)	3 (9)	2 (6)	—	—
Other, *N* (%)	2 (6)	2 (6)	—	—

APACHE II, Acute Physiology and Chronic Health Evaluation; COPD, chronic obstructive pulmonary disease.

[a]Proportions were compared using χ^2 test.

[b]Mean (SD) values were compared using analysis of *t*-test.

[c]Non-normal distribution is tested by nonparametric test.

Table 2

Tube jam rate, VAP, Mucosal injury, average diurnal aspiration volume and frequency and Patients satisfaction by randomized groups.

Variable	Time-based and on-demand management ($n=32$)	Volume-based and on-demand management ($n=31$)	$t/x^2/z$	P
Tube jam rate, *N* (%)	11 (34)	2 (6.45)	7.497	0.006[a]
VAP, *N* (%)	5 (16)	1 (3.22)	1.555	0.212[a]
Mucosalinjury			1.164	0.244[b]
Asymptomatic, *N* (%)	10 (31)	12 (38)	—	—
Local erythema, *N* (%)	12 (38)	14 (45)	—	—
Oedema, *N* (%)	7 (22)	4 (12)	—	—
Ulcer, *N* (%)	3 (9)	1 (3)	—	—
Necrosis, *N* (%)	0	0	—	—
Average aspiration volume				
Average aspiration volume of day, mean (SD) ,ml	12.68 (3.41)	12.19 (2.68)	0.637	0.527[c]
Average aspiration volume of night, M (Q_{25},Q_{75}), ml	8 (7,9)	8 (7,9)	0.876	0.860[d]
Average aspiration frequency				
Average aspiration frequency of day, *N*	9 (6,11)	7 (5,9)	4.457	< 0.001[d]
Average aspiration frequency of night, *N*	5 (4,6)	4 (3,5)	3.294	0.001[d]
Patient satisfaction				
Satisfaction of medical environment, M (Q_{25},Q_{75}), score	7 (6,8)	6 (7,8)	0.156	0.876[d]
Satisfaction of health education, M (Q_{25},Q_{75}), score	7 (6,8)	7 (6,8)	1.657	0.097[d]
Satisfaction of mental nursing , M (Q_{25},Q_{75}), score	6 (6,7)	6 (6,7)	0.079	0.937[d]
Satisfaction of operation nursing, M (Q_{25},Q_{75}), score	6 (5,7)	7 (6,7)	4.201	< 0.001[d]
Satisfaction of nursing attitude, M (Q_{25},Q_{75}), score	7 (6,8)	7 (6,8)	2.342	0.019[d]

VAP, ventilator-associated pneumonia.
[a]Proportions were compared using χ^2 test.
[b]Rank-sum test.
[c]Mean(SD) values were compared using analysis of *t*-test.
[d]Non-normal distribution is tested by nonparametric test

Patients in the ICU exhibit varying levels of airway secretions due to differences in primary diseases and age ranges, resulting in differences in body metabolism, secretion, and other physiological behaviours[14]. Factors such as obesity, underlying oral diseases, and smoking can lead to differences in the amount of subglottic secretions produced per hour, with obese patients producing more secretions than lean patients, patients with underlying oral diseases producing more secretions than asymptomatic patients, and smokers producing more secretions than non-smokers[15,16]. In addition, there are significant variations in the diurnal secretion of subglottic secretions among patients in the ICU due to differences in individual diurnal metabolism and treatment measures[17]. Thus, time-based management modes of subglottic secretions cannot accurately manage individual patients or conform to the core concept of case-by-case management in the ICU treatment unit. Furthermore, due to the unique circadian treatment behaviours of patients in the ICU, time-based management models cannot fully address the variations in subglottic secretions due to the patients' circadian rhythm.

For patients with mechanical ventilation, subglottic secretions production is the key factor affecting the occurrence of VAP[18], but for the ICU patients, individual differences determines the obvious difference in secretion production. This study explored a precise management mode for subglottic secretions in mechanically ventilated patients and conducted a clinical application study of an individualized management mode based on patients' secretion production. The results showed that the individualized management mode of subglottic secretions can effectively prevent the occurrence of VAP and reduce adverse reactions associated with traditional management modes. Additionally, it can improve the flexibility of subglottic secretion intervention strategies to a certain extent. The reasons are as follows: (1) precise scientific management mode: Based on the time management of the patients with subglottic secretion is not only ignored the individual differences of patients, but also reduced the intervention strategy of flexibility. Individual difference in ICU patients is the root cause of the difference of subglottic secretion[19]. In this study, individualized aspiration frequency based on the secretion of patients could not only achieve timely removal of secretions to reduce duct blockage and reduce the risk of VAP events, but also avoid the occurrence of local mucosal injury events caused by continuous suction to some extent. In addition, the management mode of supplementing on-demand suction during mechanical ventilation for these patients also directly improves the safety of subglottic secretions management.(2) The rationality of the precision management mode: Under normal circumstances, the physiological metabolism of the body is characterized by diurnal differences, while the diurnal differences of patients in ICU are more significant due to the special environment, drug treatment and other factors[20]. In this study, the diurnal metabolic differences of the two groups were jointly discussed, and it was found that the average pumping frequency and pumping volume in the day were higher than in the night, which further confirmed the characteristics of diurnal differences in subglottic secretions production in ICU patients. In this study, the precision management mode further verified the rationality of the management scheme by jointly exploring the differences in patients' diurnal metabolism.(3) The applicability of the precision management mode: Different patients also have different tolerance to subglottic secretion stimulation, especially for critically ill patients with different degrees of consciousness disorder, although

consciousness disorder increases the tolerance of secretion stimulation to some extent, it also increases the risk of adverse events such as aspiration. However, the management mode based on fixed time cannot achieve the purpose of timely and effective removal of subglottic secretion, which will directly increase the discomfort of patients during the treatment and the risk of adverse events[21,22]. In addition, some severe patients even have the risk of vomiting and other events during the treatment, especially for the severe patients assisted with enteral nutrition during mechanical ventilation, which will further increase the risk of aspiration and other events. Precise management mode, however, the precision management model not only develops the individual management based on the patient's secretion production, but also cooperates with the on-demand management model, in clinical practice, medical staff can not only clear secretions in time, bring good treatment experience to patients, but also improve the flexibility of management strategies to a certain extent, and then improve the safety of patients' treatment.

Impact statements

Subglottic secretion drainage is one of the effective measures to prevent ventilator-associated pneumonia. At present, there are two main management modes of subglottic drainage: continuous and intermittent. Both models are time-based secretion management and each has advantages and disadvantages. However, they cannot reflect the individual differences of ICU patients and the intervention strategy is lack of flexibility. The precise management mode explored in this study based on individual patients can not only take into account the advantages and disadvantages of traditional mode, but also give full play to the flexibility and predictability of intervention strategy, and further optimize the treatment scheme of mechanical ventilation for ICU patients.

Conclusions

VAP is the most serious complication of mechanical ventilation and is caused by many risk factors, and subglottic secretion is an important risk factor. In this study, Based on the amount of secretion produced by patients and with the management strategy of attracting on demand, for medical staff, through the accurate evaluation of the amount of subglottic secretions produced by patients, we can achieve predictable intervention effect in clinical practice. For patients, it can timely and effectively clean the subglottic secretion, reduce the risk of aspiration and other events, and bring patients a good treatment experience. In this study, the precise management strategy based on patient secretions production is the inheritance and development of the traditional management mode, which aims to further optimize the management scheme of patients' subglottic secretions, So as to improve the safety of patient treatment.

Limitations

At present, this study is only applied to a small sample of patients in our hospital. In order to further clarify the rationality and scientificity of the research scheme, it needs to be verified by clinical multi-centre application.

Ethical approval

This study has been approved by the Ethics Committee of Zigong Fourth People's Hospital (approval number: 2022-035).

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Source of funding

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Author contribution

D.J. was mainly responsible for the writing of the original paper, data collection and statistical analysis. N.C. was mainly responsible for document revision, research design and quality control. W.X. mainly works in data receipt collection, follow-up investigation and research design.

Conflicts of interest disclosure

There are no conflicts of interest.

Research registration unique identifying number (UIN)

Trial registration number: ChiCTR2200067237.

Guarantor

Du Jinlei is the guarantor of this study.

Data availability statement

All the data generated in this study can be used. Meanwhile, we also upload the original data as an attachment for review.

Provenance and peer review

Peer review of this paper has been invited.

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