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Original Article

The effect of airway suction nursing care for COPD patients with airway mucus hypersecretion

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Abstract: Objective: To study the effect of airway suction nursing care for patients with chronic obstructive pulmonary disease (COPD) and airway mucus hypersecretion. Methods: A total of 116 COPD patients with airway mucus hypersecretion were recruited and divided into the control group and the observation group by a random number table method, with 58 cases in each group. The patients in the control group received conventional treatment and nursing care. In addition to the treatment given to the control group, the patients in the observation group were also given special airway suction nursing, which mainly included "wet, patting, drainage, turning". The total effective rates of the airway suction nursing, length of hospital stay, COPD assessment test (CAT) scores, nursing satisfaction scores, arterial blood gas indexes, lung function indexes and serum inflammatory factor levels before and after treatment were compared. Results: Compared to the control group, the observation group had significantly higher total effective treatment rate (98.28% vs 84.48%), arterial blood oxygen partial pressure PO_2 and oxygenation index (PaO_2/FiO_2), and significantly lower arterial blood carbon dioxide partial pressure PCO_2 (all $P<0.05$). The lung function indicators in the observation group were significantly higher than that in the control group (all $P<0.001$). Serum procalcitonin, hypersensitive C-reactive protein, tumor necrosis factor-α levels as well as the hospital stay and CAT score in the observation group were significantly lower than those in the control group (all $P<0.001$). Conclusion: Special airway suction nursing can significantly improve the quality of sputum discharge in COPD patients with airway mucus hypersecretion, enhance the quality of lung ventilation, improve the arterial blood gas, reduce the body's inflammatory response and accelerate the recovery of patients. Therefore, it is worthwhile to promote the application of airway suction nursing care in clinic.

Keywords: Airway suction, airway suction nursing, COPD, airway mucus hypersecretion, effect of nursing care

Introduction

Chronic obstructive pulmonary disease (COPD) is an infectious lung disease, the pathologic characteristics of which are persistent airway airflow restriction. COPD is usually progressive and may involve the alveoli, interstitial lung, and terminal airways. It causes a severe inflammatory response, which manifests as cough, sputum, fever, and other symptoms. Complications such as pulmonary hypertension, chronic pulmonary heart disease, and even death from respiratory failure can occur in severe patients [1]. According to research, the incidence rate of COPD is increasing annually, having the characteristics of a high hospitalization rate and high fatality rate. It is estimated that by 2020, COPD will become the third leading cause of death globally. Pathological studies have confirmed that airway mucus hypersecretion is a common pathophysiological manifestation of COPD patients with acute exacerbation [2]. The persistent hypersecretion of mucus leads to its accumulation in the respiratory tract and the viscosity of sputum increases the difficulty of coughing, which results in the formation of a mucus plug. The mucus plug can aggravate airway airflow obstruction, leading to progressive damage to lung function, causing disturbances in the body's blood oxygen balance, and aggravating the lung inflammation. Additionally, sputum stasis also induces advantageous breeding conditions for pathogenic bacteria, leading to repeated lung inflammation and thus forming a vicious cycle of disease.

Current research has proved that airway mucus hypersecretion may exist in all stages of the development of COPD, this is an important pathophysiological feature, and has also been confirmed as an independent risk factor affecting the condition and prognosis of COPD [3]. At present, COPD patients often need assistance with ventilation treatment, and as such daily activities of patients are limited. Long-term immobilization increases the stasis of sputum in lungs, which induces secondary infections of pathogenic bacteria in the lungs. Eventually, the airway obstruction and disease condition are exacerbated. Thus, keeping the airway unobstructed is particularly important to improve the prognosis of COPD patients. At present, conventional nursing gives insufficient attention to airway sputum drainage. Special airway suction nursing can significantly improve the pertinence and effectiveness of sputum suction care. A study found that special nursing for airway sputum suction can significantly improve the quality of sputum discharge in patients with pulmonary infectious diseases, accelerate the recovery of the disease, and improve patients' quality of life, but clinical nursing experience is still limited [4]. Therefore, this article carried out research based on this nursing method, aiming to provide guidance for the selection of optimal clinical nursing methods.

Materials and methods

Participants

The participants of this study were 116 COPD patients with airway mucus hypersecretion, who were admitted to The Second Affiliated Hospital of Hainan Medical University from February 2018 to February 2020, and they were divided into the control group and the observation group by a random number method, with 58 cases in each group. This study was approved by the Ethics Committee of The Second Affiliated Hospital of Hainan Medical University.

Inclusion criteria: Patients met the clinical diagnostic standards related to COPD [5]; patients met the diagnostic standards related to airway mucus hypersecretion [6]; patients with no serious organ diseases such as cardiovascular, cerebrovascular, liver and kidney diseases; patients volunteered to participate in this study and signed informed consent.

Exclusion criteria: Patients with lung cancer, bronchial asthma and other serious respiratory diseases; patients with airway obstruction caused by other factors such as cerebrovascular accidents and left heart failure; patients with poor compliance who could not cooperate well with treatment and care.

Nursing methods

In accordance with the relevant standards in the COPD treatment and care guidelines, both groups of patients were given routine treatment and care, including bronchodilators, expectorants, hormones, and antibacterial drugs; and were maintained in a comfortable environment in the ward, with psychological guidance, assisting in cough and expectoration, posture drainage, and atomization inhalation.

Patients of the observation group were given special care for airway sputum suction, including four steps; "wet, patting, drainage, turning".

Wet: Encourage patients to develop good drinking habits, drinking 2,500-3,000 mL of water a day, on several occasions. If necessary, give intravenous rehydration, and avoid drinking dairy products. The bed was raised at an angle of about 30° so that the patient's cervical spine was in a horizontal position. They inhaled a mixed solution of 20 mL 0.9% NaCl injection and 30 mg ambroxol (Shanghai Boehringer Ingelheim Pharmaceutical Co., Ltd., H20130779, 2 mL/15 mg) for 15 min/time, once in the morning and evening. During the inhalation, the nurse paid close attention to coughing and breathing to avoid suffocation caused by sputum accumulation. A warm water bottle is used to humidify and warm the oxygen, the humidity is controlled at 50% to 60%, and the temperature is controlled at about 32°C to keep the respiratory tract warm and moist, and to improve the oxygen diffusion capacity.

Patting: The position of sputum retention in the lungs was determined and the nurse provided correct assist in patting the back to help the sputum discharge, including manual tapping and a vibrating sputum discharge machine. The manual tapping referred to the nurses using the wrist to gently and quickly tap the patients' back from top to bottom and from both sides to the middle during the breathing phase, 3 to 5

times in each exhalation phase, lasting for 5 to 15 min. If the patients used a vibrating sputum excretion machine to assist in sputum discharge, the tapping should be done with a sponge or rubber material and the vibration frequency was about 20-35 times/s and the vibration started from the lower lung, and then upward and inward, lasting 15 min each time. The vibrating sputum excretion machine could be used 1-6 times a day according to the condition of the patient. During this period, the nurses closely observed the patient's breathing and complexion.

Drainage: Postural drainage was used to improve the effect of sputum discharge. The posture of patients was changed to help the patient's position, with the bronchial orifice downward, and thus draining the sputum by gravity, 10-15 min/time, 1-2 times/day, usually in the morning or night. During the drainage process, the nurses closely observed whether patients have palpitations and shortness of breath.

Turning: The nurses turned the patient over regularly every 2-3 h. When they slowly turn over, the nurses tap the back so that patients might cough at the same time. The patient's were turned to the most comfortable position. For the unconscious patient, oral secretions were completely removed before turning over, avoiding accidental inhalation or suffocation.

Outcome measures

Main outcome measures: The total effective rate of nursing between the two groups of patients was compared. According to the clinical standard [7], the nursing effect is divided into three levels. First, significantly effective: the patient's body temperature returned to normal; patients had only a light cough, a small amount of white foamy sputum which was easy to cough out; symptoms such as difficulty in breathing were significantly relieved; only slight rales were heard on auscultation, and X-ray showed complete absorption of inflammation in the lungs. Second, effective: the patient's body temperature returned to normal; patients had paroxysmal cough, accompanied by white sticky sputum which was not easy to cough out; symptoms such as difficulty in breathing are relieved; scattered rales were heard on auscultation, and X-rays showed that the inflammation of the two lungs was absorbed. Third, ineffective: the patient's symptoms such as cough, sputum, and dyspnea, and the signs of rales and fever were not alleviated or worsened. The total effective rate of nursing = (significantly effective + effective) number of cases/total number of cases * 100%.

The levels of PO_2, PCO_2 and PaO_2/FiO_2 before and after nursing care were compared between two groups of patients when they are in resting states. Arterial blood, blood gas indicators such as PO_2, PCO_2 and PaO_2/FiO_2 were measured with ABL800 blood gas analyzer (Danish Ledo).

The levels of lung function indexes such as MVV, FEV_1, FEV_1/FVC before and after nursing care were compared between two groups of patients. The detection instrument was a Japanese Foton ST-75 lung function instrument (Shanghai Hanfei Medical Instrument Co., Ltd.).

The levels of PCT, hs-CRP, TNF-α and other inflammatory factors before and after nursing were compared between the two groups of patients. About 5 mL of peripheral venous blood were collected from patients in a fasted state and the blood samples were centrifuged at 3,000 r/min for 10 min to extract serum. The serum PCT, hs-CRP and TNF-α levels were then detected by enzyme-linked immunosorbent assay (ELISA). The kit was produced by Nanjing Camilo Bio Produced by Engineering Co., Ltd.

Secondary outcome measures: The length of hospital stay, COPD assessment test (CAT) score and nursing satisfaction score of the two groups of patients were compared. The CAT scale includes 8 items, and each item has a score of 0 to 5 points, with a full score of 40 points. The score indicates the impact of COPD on the quality of life. The score of 20-30 points is regarded as severe influence, and 30-40 is regarded as an extremely severe influence. The scale is filled out by the patient. Nursing satisfaction was evaluated using a questionnaire survey designed by The Second Affiliated Hospital of Hainan Medical University. The full score is 100 points and a high score means a high nursing satisfaction level.

Statistical methods

All statistical data were analyzed using SPSS 21.0 professional statistical software. Measu-

Table 1. Comparison of characteristics

Groups	Gender (male/female)	Average age (years)	Disease course (years)
Control group (n=58)	33/25	61.7±10.7	6.4±2.1
Observation group (n=58)	32/26	62.1±10.6	6.5±2.2
t/χ^2	χ^2=0.409	t=0.355	t=0.293
P	0.721	0.769	0.815

Table 2. Comparison of total effective rates

Groups	Significant effective	Effective	Ineffective	Total effective rate (%)
Control group (n=58)	35 (60.34)	14 (24.14)	9 (15.52)	49 (84.48)
Observation group (n=58)	52 (89.66)	5 (8.62)	1 (1.72)	57 (98.28)
χ^2				6.532
P				0.011

Table 3. Comparison of levels of arterial blood gas indexes ($\bar{x}$ ± sd)

Indexes	Control group (n=58)	Observation group (n=58)	t	P
PO_2 (mmHg)				
Before care	54.26±8.37	55.03±8.43	0.467	0.641
After care	82.19±6.58*	91.85±6.93*	7.289	<0.001
PCO_2 (mmHg)				
Before care	65.38±6.70	66.12±6.86	0.344	0.731
After care	55.71±5.03*	43.08±4.62*	13.335	<0.001
PaO_2/FiO_2				
Before care	135.60±10.33	134.38±11.47	0.156	0.876
After care	291.42±15.76*	331.84±16.93*	12.601	<0.001

Notes: Compared with that before care within groups, *P<0.05. PO_2: arterial blood oxygen partial pressure; PaO_2/FiO_2: oxygenation index; PCO_2: arterial blood carbon dioxide partial pressure.

rement data were expressed as mean ± standard deviation ($\bar{x}$ ± sd). Independent sample t test was used for comparison between groups and paired t test was used for comparison within groups. All enumeration data were expressed as number of cases (percentage, n, %), and the χ^2 test was used to compare between groups. P<0.05 was considered statistically significant.

Results

Comparison of patient characteristics

In the control group, there were 33 males and 25 females with an average age of (61.7±10.7) years and an average disease course of (6.4±2.1) years. There were 32 males and 26 females in the observation group, with an average age of (62.1±10.6) years and an average disease course of (6.5±2.2) years. There was no significant difference in gender, age and disease course between the two groups of patients (P>0.05, **Table 1**).

Comparison of total effective rate in patients

The total effective rate of nursing for patients was 98.28% in the observation group, which was significantly higher than that (84.48%) in the control group. For details, see **Table 2**.

Comparison of the levels of arterial blood gas indexes before and after nursing care

Before nursing, there were no significant differences in PO_2, PCO_2 and PaO_2/FiO_2 between the two groups of patients (all P>0.05). After nursing, PO_2 and PaO_2/FiO_2 of the observation group were significantly higher than that in the control group; conversely, PCO_2 of the observation group was significantly lower than that in the control group (P<0.001). Details were listed in **Table 3** and **Figure 1**.

Comparison of the levels of lung function indexes before and after nursing care

Before nursing there was no significant difference in MVV, FEV_1 and FEV_1/FVC between the two groups of patients (all P>0.05). After nursing, the MVV, FEV_1 and FEV_1/FVC of the observation group were significantly higher than those in the control group (all P<0.001). The details were shown in **Table 4** and **Figure 2**.

Comparison of the levels of inflammatory indexes before and after nursing care

The serum PCT, hs-CRP and TNF-α levels of the two groups before nursing were not significant-

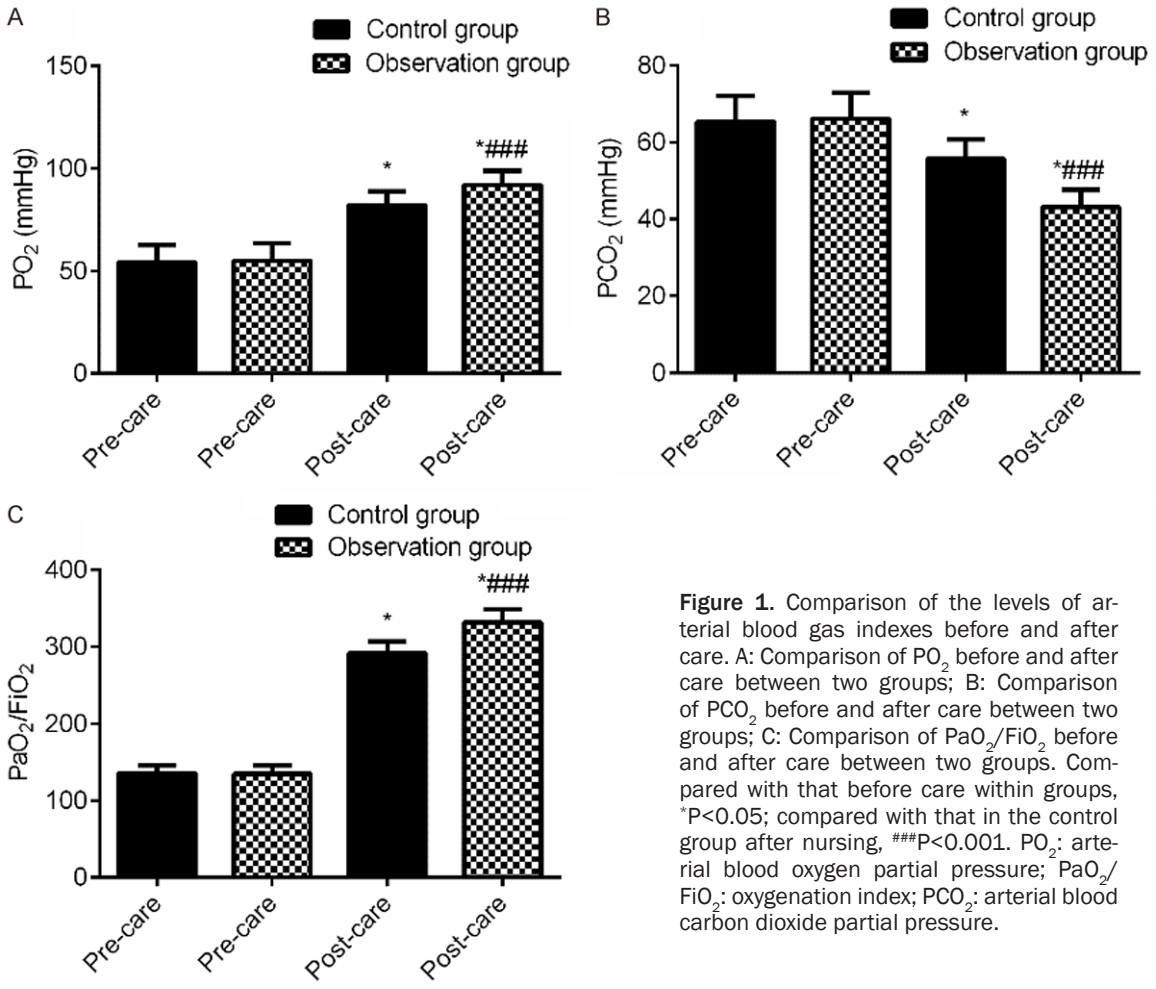

Figure 1. Comparison of the levels of arterial blood gas indexes before and after care. A: Comparison of PO_2 before and after care between two groups; B: Comparison of PCO_2 before and after care between two groups; C: Comparison of PaO_2/FiO_2 before and after care between two groups. Compared with that before care within groups, *P<0.05; compared with that in the control group after nursing, ###P<0.001. PO_2: arterial blood oxygen partial pressure; PaO_2/FiO_2: oxygenation index; PCO_2: arterial blood carbon dioxide partial pressure.

Table 4. Comparison of levels of lung function indexes before and after nursing care ($\bar{x}$ ± sd)

Indexes	Control group (n=58)	Observation group (n=58)	t	P
MVV (L)				
Before care	76.27±8.64	76.81±8.59	0.727	0.469
After care	86.75±10.43*	99.64±12.18*	5.797	<0.001
FEV_1 (L)				
Before care	1.42±0.38	1.40±0.37	0.614	0.541
After care	1.87±0.50*	2.41±0.56*	5.187	<0.001
FEV_1/FVC (%)				
Before care	65.58±10.57	64.96±10.70	0.149	0.882
After care	74.98±11.45*	84.04±12.18*	3.925	<0.001

Notes: Compared with that before care within groups, *P<0.05. MVV: maximum ventilation volume per minute; FEV_1: maximum forced expiratory volume in 1 second; FEV_1/FVC: the ratio of maximum forced expiratory volume in 1 second to forced vital capacity.

ly different (all P>0.05). After nursing, the serum PCT, hs-CRP and TNF-α levels of the observation group were significantly lower than those in the control group (all P<0.001). The details were shown in **Table 5** and **Figure 3**.

Comparison of hospital stay, CAT sores and nursing satisfaction scores between two groups

The hospital stays and CAT score of the observation group were significantly lower than those of the control group (all P<0.001), and the nursing satisfaction scores of the observation group was significantly higher than that of the control group (P<0.001). For details, see **Table 6**.

Discussion

Current research has proved that airway mucus hypersecretion can exist in all stages of COPD,

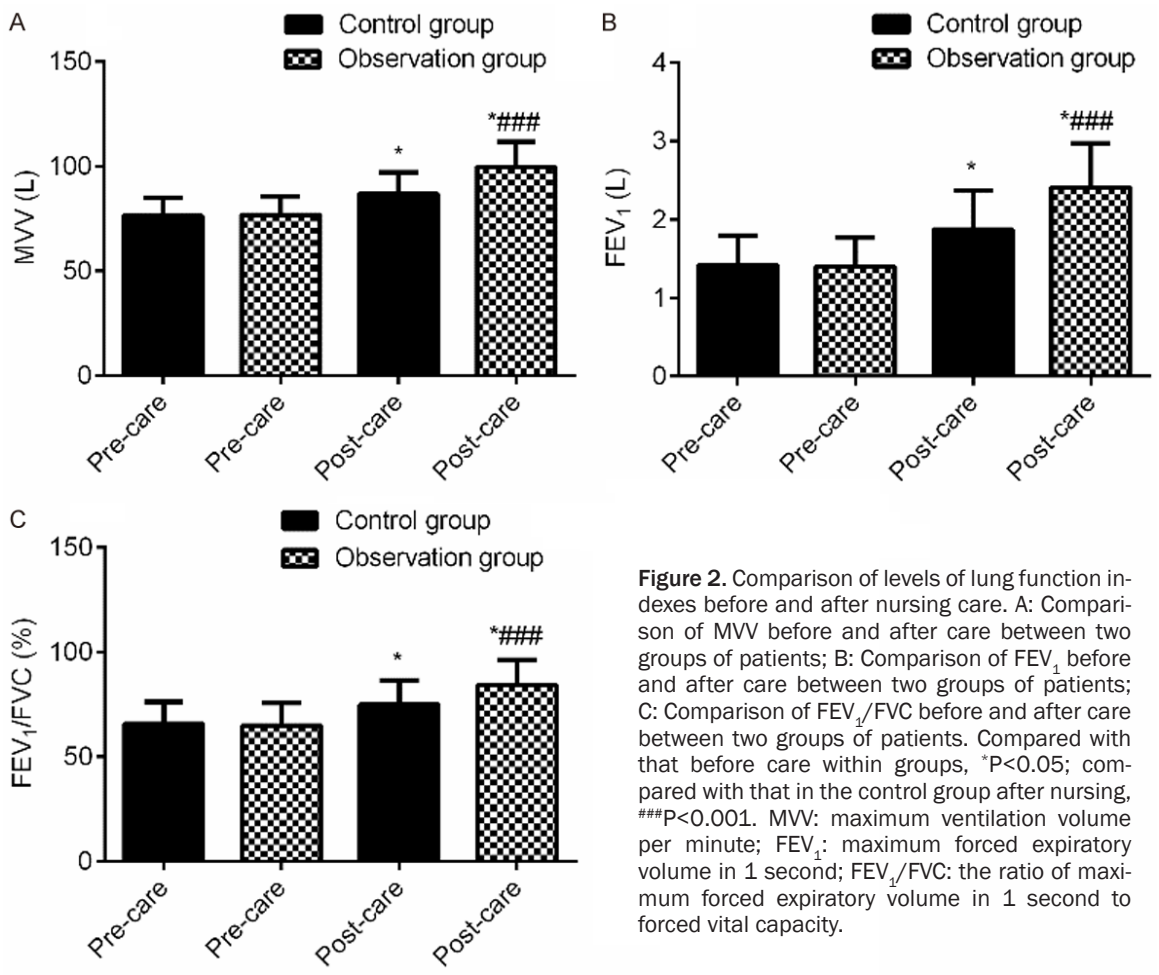

Figure 2. Comparison of levels of lung function indexes before and after nursing care. A: Comparison of MVV before and after care between two groups of patients; B: Comparison of FEV_1 before and after care between two groups of patients; C: Comparison of FEV_1/FVC before and after care between two groups of patients. Compared with that before care within groups, *P<0.05; compared with that in the control group after nursing, ###P<0.001. MVV: maximum ventilation volume per minute; FEV_1: maximum forced expiratory volume in 1 second; FEV_1/FVC: the ratio of maximum forced expiratory volume in 1 second to forced vital capacity.

Table 5. Comparison of levels of inflammatory factors before and after nursing care ($\bar{x}$ ± sd)

Indexes	Control group (n=58)	Observation group (n=58)	t	P
PCT (μg/L)				
Before care	1.50±0.27	1.47±0.31	0.304	0.762
After care	0.33±0.09*	0.12±0.04*	15.376	<0.001
hs-CRP (mg/L)				
Before care	2.11±0.45	2.09±0.48	0.119	0.905
After care	1.41±0.29*	1.02±0.20*	7.983	<0.001
TNF-α (ng/mL)				
Before care	3.08±0.56	3.12±0.53	0.239	0.812
After care	2.11±0.40*	1.54±0.35*	7.733	<0.001

Notes: Compared with that before care within groups, *P<0.05. PCT: procalcitonin; hs-CRP: hypersensitive C-reactive protein; TNF-α: tumor necrosis factor-α.

which is an important pathophysiological feature and an independent risk factor affecting the condition and prognosis of COPD [8]. The research of JP Allinson et al. confirmed that mucus hypersecretion was accompanied by the development of COPD [9]. With the disease duration prolonged, the patients' lung function indexes such as FEV_1 severely decrease. There was a significant positive correlation. At the same time, it was found that smoking cessation, active treatment, and other measures can effectively reduce the hypersecretion of mucus. Studies have confirmed that the removal of respiratory sputum can improve the quality of lung ventilation, enhance lung function and exercise endurance, and can directly reduce the risk of acute exacerbation of COPD [10]. Eliminating phlegm is the key to maintaining the patency of the patient's respiratory tract, improving the quality of lung ventilation, reducing inflammation, and promoting recovery [11]. At present, conventional nursing gives insufficient attention to airway sputum drainage, which affects the effect of expecto-

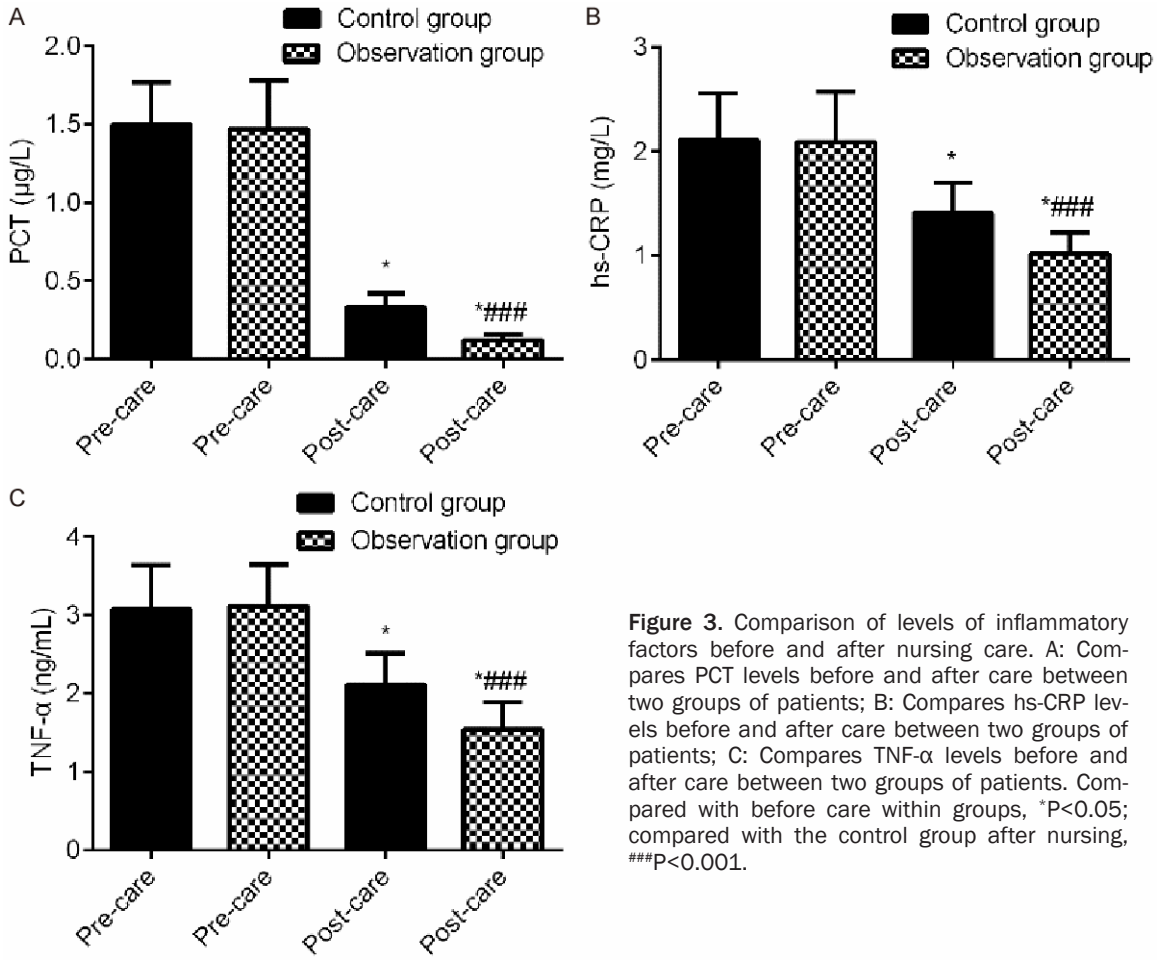

Figure 3. Comparison of levels of inflammatory factors before and after nursing care. A: Compares PCT levels before and after care between two groups of patients; B: Compares hs-CRP levels before and after care between two groups of patients; C: Compares TNF-α levels before and after care between two groups of patients. Compared with before care within groups, *P<0.05; compared with the control group after nursing, ###P<0.001.

Table 6. Comparison of hospital stay, CAT sores and nursing satisfaction scores ($\bar{x}$ ± sd)

Groups	Hospital stays (d)	CAT sores	Nursing satisfaction scores
Control group (n=58)	16.81±3.47	24.18±6.52	78.62±8.79
Observation group (n=58)	10.49±3.35	12.56±3.49	96.91±3.07
t	9.476	12.487	14.166
P	<0.001	<0.001	<0.001

Notes: CAT: obstructive pulmonary disease assessment test.

rant treatment. Therefore, searching for more effective nursing programs has become a clinical focus.

Special airway suction nursing is a nursing method that emphasizing the effectiveness and pertinence of sputum suction care, and focuses on improving the quality of sputum suction [12], but there is little research about its application in COPD patients with airway mucus hypersecretion. In this study, the four steps of "wet, patting, drainage, turning" are used. First, the patient's airway is humidified, including drinking water frequently, nebulized inhalation, and humidifying oxygen, etc., which helps to moisten the respiratory tract mucosa, accelerate the excretion of sputum from the body, and enhance the efficacy of oxygen therapy. At the same time, the nurse can raise the bed by 30°, determine the position of the sputum according to the results of the auxiliary examination, and combine measures such as turning the patient over, tapping the back, and using a vibrating sputum discharge machine to let gravity promote sputum drainage and coughing.

However, Cabillic et al. pointed out that it is difficult to achieve satisfactory results with pure

postural drainage [13]. The postural drainage can be combined with mechanical vibration sputum discharge and atomization inhalation to improve the sputum discharge effect. In this study, ambroxol atomization inhalation was used, which has multiple effects such as inhibiting secretion of airway mucus cell, promoting cilia movement, promoting expression of alveolar surfactant and relaxing the respiratory tract, etc., so as to inhibit secretion of airway mucus and dilute sputum, but the effect of promoting excretion of sputum is ordinary [14-16]. Therefore, this study also uses a vibratory sputum excretion machine to assist sputum excretion, which can generate a vertical tapping force and horizontal directional force on the thoracic surface, effectively penetrating the tissue resistance, and the vibration can directly reach the small bronchus, thereby helping the discharge of airway sputum.

Studies of YX Guan et al. have shown that special sputum suction nursing can help make nursing more targeted and effective [17]. While promoting the discharge of pulmonary sputum, it can enhance the efficacy of oxygen therapy and other treatment measures and improve arterial blood gas and lung function. Our study showed that the total effective rate of nursing care in the observation group was significantly higher than that in the control group, and the hospital stay lenght and CAT score in the observation group were significantly lower than that in the control group. While the nursing satisfaction score in the observation group was significantly higher than that in the control group, confirming that airway suction nursing can improve the overall quality of care, can improve the sputum discharge effect of patients, accelerate the recovery of clinical symptoms and signs, and improve the quality of life. In addition, patients felt greater satisfaction with special sputum suction nursing care.

At the same time, our study showed that PO_2 and PaO_2/FiO_2 of the observation group were significantly higher than that of the control group. While, PCO_2 of the observation group was significantly lower than the control group. Lung function indicators such as MVV, FEV_1 and FEV_1/FVC of the observation group were all significantly higher than that of the control group, suggesting that special airway suction nursing can improve the quality of sputum discharge, improve systemic blood oxygen metabolism disorders, enhance the quality of lung ventilation, and remove airway sputum in a timely manner, improve the patency of lung ventilation and can ensure adequate oxygen supply to all important organs of the body [18]. Bian Xuqing et al. also pointed out that the effective promotion of sputum excretion can significantly improve the recovery of lung function in patients with infectious lung diseases and regulate the systemic blood oxygen balance, which is basically consistent with the results of this study [19].

At the same time, our results indicated that the serum levels of PCT, hs-CRP and TNF-α in the observation group after nursing were significantly lower than that in the control group, suggesting that special airway suctioning nursing care can also inhibit lung inflammation. It is possibly that clearance of sputum destroyed the growth environment of pathogenic bacteria, and inhibited bacterial reproduction, thereby reducing inflammation and the impact of inflammation on lung function, and promoted the patients' recovery [20-22].

In this study, due to the small sample size and the lack of standard protocols for the evaluation of COPD patients with airway mucus hypersecretion, the actual sputum volume and lung function of the two groups may not be completely different. So, the results are affected by uncontrollable variables. In the future, we will increase the sample size and optimize inclusion criteria to improve the reliability of results.

In conclusion, for COPD patients with airway mucus hypersecretion, special airway suction nursing can significantly improve the quality of sputum discharge, enhance the quality of lung ventilation, improve arterial blood gas, reduce the body's inflammatory response and accelerate the recovery of the patient. Therefore, special airway suction nursing care is worthy of clinical promotion.

Disclosure of conflict of interest

None.

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