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Effects of Standardized Bronchoscopic Interventional Therapy on Efficacy and Degree of Stenosis in Patients with Airway Stenosis

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Abstract: *Objective:* To analyze the treatment effect of standardized bronchoscopic interventional therapy (i.e., interventional therapy) on airway stenosis. *Methods:* Forty patients with airway stenosis admitted to the hospital between September 2022 and September 2024 were selected and randomly divided into two groups using a random number table. The experimental group received interventional therapy, while the reference group received conventional treatment. The total effective rate, degree of airway stenosis, shortness of breath score, and lung function indicators were compared. *Results:* The total effective rate in the experimental group was higher than that in the reference group. The proportion of mild stenosis in the degree of airway stenosis was higher in the experimental group than in the reference group. The shortness of breath score was lower in the experimental group than in the reference group. The lung function indicators were better in the experimental group than in the reference group ($P < 0.05$). *Conclusion:* Interventional therapy is effective for patients with airway stenosis, as it can reduce the degree of stenosis, improve symptoms of shortness of breath, and protect patients' lung function.

Keywords: Standardized bronchoscopic interventional therapy; Airway stenosis; Therapeutic effect; Degree of stenosis

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1. Introduction

The etiology of airway stenosis is complex, including sarcoidosis, long-term endotracheal intubation, airway tuberculosis, or tracheotomy, manifesting as extrinsic airway stenosis or large airway obstruction. Patients with this disease commonly experience symptoms such as dyspnea and shortness of breath and are prone to complications such as atelectasis or obstructive pneumonia [1]. Bronchoscopic intervention is a novel minimally invasive therapy for this disease that utilizes standardized and normalized interventional treatment processes to accurately locate stenotic lesions, determine the scope of stenosis, and select the optimal treatment plan to improve efficacy. Additionally, interventional therapy can precisely evaluate the intubation angle and depth, understand catheter position, and provide guidance for catheter placement plans, significantly reducing the degree of stenosis and addressing the disease's etiology [2]. This therapy offers diversified treatment approaches that can alleviate disease severity through multiple mechanisms, resulting in significant therapeutic effects. Based on this, the study selected 40 patients with airway stenosis to evaluate the implementation effect of interventional therapy.

2. Materials and methods

2.1. General information

Forty patients with airway stenosis admitted to the hospital between September 2022 and September 2024 are selected and randomly divided into two equal groups using a random number table. The experimental group consisted of 20 patients, including 12 males and 8 females, with an age range of 34–69 years and a mean age of (52.15 ± 4.19) years. The duration of illness ranged from 10–77 days, with a mean of (45.36 ± 7.94) days. The length of airway stenosis ranged from 1.05–3.41 cm, with a mean of (2.04 ± 0.52) cm. The reference group also consisted of 20 patients, including 11 males and 9 females, with an age range of 33–67 years and a mean age of (52.20 ± 4.21) years. The duration of illness ranged from 11–79 days, with a mean of (45.97 ± 7.80) days. The length of airway stenosis ranged from 1.01–3.45 cm, with a mean of (2.08 ± 0.53) cm. There were no statistically significant differences in baseline characteristics between the two groups ($P > 0.05$).

The inclusion criteria of the study are: comprehensive diagnosis of benign airway stenosis based on CT scan, pathological examination, and clinical signs; meeting the indications for bronchoscopic intervention; patient age less than 80 years old; normal cognitive function and consciousness state; complete clinical data; fully informed about the study. Meanwhile, the exclusion criteria of the study are: outpatient treatment; juvenile patients; patients with malignant tumors; presence of contraindications for treatment; participation in other studies.

2.2. Methods

The control group chose conventional treatment: assisting patients to complete relevant examinations such as electrocardiogram, chest CT, and coagulation function. Balloon dilation therapy is performed on the stenotic lesion, with each dilation lasting 2–4 minutes and repeated 2–3 times. Additional dilation treatments are administered on the 8th, 15th, and 22nd days.

The experimental group chose interventional therapy: After assisting the patients to complete relevant examinations and ensuring that they meet the indications for bronchoscopic intervention, patients are required to fast for 8 hours, underwent localized intravenous anesthesia, and had a bronchoscope slowly and accurately inserted through the nasal cavity. A venous channel is established for oxygen therapy with an oxygen flow rate of 2–3L per minute. Patient vital signs were monitored throughout.

Standardized therapies included:

(1) Cryotherapy: The bronchoscope is guided to the stenotic lesion, inflammatory material and necrotic tissue in the area were removed, and a cryoprobe is inserted through the endoscopic channel directly to the lesion. The cryopreservation system is activated to freeze and thaw the lesion tissue for 5 minutes, turning it into ice. This process is repeated 1–3 times until the lesion was completely frozen, and then the probe was removed. Cryotherapy is performed once every week for 4 weeks.

(2) Balloon dilation: After anesthesia, a bronchoscope is placed at the stenotic site, a guidewire is inserted, and an appropriately sized balloon catheter is slowly inserted along the guidewire to the lesion site. A suitable

amount of normal saline is injected into the balloon for pressurization therapy, with the pressure level adjusted according to the degree of stenosis. The recommended atmospheric pressure is 3–5 atmospheres. The dilation is maintained for 1–2 minutes and repeated 2–3 times before removing the balloon. Balloon dilation therapy is performed once every week for 4 weeks.

(3) Argon plasma treatment: An electrode is placed on the distal end of the patient's lower extremity (unilateral), and the argon plasma device is connected. The air velocity is adjusted appropriately, and the electrode is inserted through the original bronchoscope channel. The coagulation treatment power is set at 20–60W, ensuring that the oxygen concentration is less than 35%. The treatment frequency is the same as above.

(4) High-frequency electric knife treatment: A curved bronchoscope is placed at the stenosis, and an appropriate electric knife is used for multiple treatments on the stenotic lesion.

(5) Stent implantation: A covered stent is placed in the biopsy hole, and the inserter is slowly placed inside the airway. The stent position is adjusted appropriately to expand the airway.

2.3. Observation indicators

(1) Degree of airway stenosis: CT scans are performed, and the stenosis range is evaluated using multi-planar reconstruction (MPR) and curved planar reconstruction (CRP) images. The stenosis degree is calculated as follow: (diameter of the proximal end of the stenosis – minimum diameter of the stenotic segment) ÷ diameter of the proximal end of the stenosis * 100%. Mild stenosis refers to a degree not exceeding 25%, moderate stenosis ranges from 26–75%, and severe stenosis exceeds 75%.

(2) Shortness of breath score: Grade 0 indicates no shortness of breath, scoring 0 points; Grade 1 indicates shortness of breath symptoms during fast walking, scoring 1 point; Grade 2 indicates shortness of breath symptoms during normal walking, scoring 2 points; Grade 3 indicates obvious shortness of breath and difficulty breathing during normal walking, scoring 3 points; Grade 4 indicates severe shortness of breath during mild activity, scoring 4 points.

(3) Lung function indicators: Lung function tester is used to measure the forced expiratory volume in one second (FEV1), maximum lung capacity (VCmax), and forced vital capacity (FVC).

The above indicators are evaluated both before treatment and one month after treatment.

2.4. Therapeutic effect evaluation criteria

(1) Complete effectiveness: Normal bronchial function, no airway stenosis

(2) Partial effectiveness: Significant improvement in bronchial function, stenosis improvement exceeding 50%, significant improvement in subjective symptoms

(3) Mild effectiveness: Improvement in bronchial function, stenosis improvement less than 50%, improvement in subjective symptoms

(4) No effect: No change in bronchial function, no improvement in stenosis or subjective symptoms.

2.5. Statistical analysis

Data are processed using SPSS 28.0 software. Measurement data are expressed as [$\bar{x}$ ±s], and compared and tested using t-values. Count data are expressed as numbers and percentage [n/%], and compared and tested using chi-square (x^2) values. Statistical significance is set at $P < 0.05$.

3. Results

3.1. Comparison of the total effective rate between the two groups

The total effective rate of the experimental group was higher than that of the reference group ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of the total effective rate between the two groups [n/%]

Group	Number of cases	Completely effective	Partially effective	Mildly effective	No effect	Total effective rate
Experimental group	20	10 (50.00)	5 (25.00)	4 (20.00)	1 (5.00)	95.00 (19/20)
Control group	20	7 (35.00)	4 (20.00)	3 (15.00)	6 (30.00)	70.00 (14/20)
x^2	-	-	-	-	-	4.329
P	-	-	-	-	-	0.038

3.2. Comparison of the degree of airway stenosis between the two groups

The proportion of mild stenosis in the experimental group was higher than that in the reference group ($P < 0.05$), as illustrated in **Table 2**.

Table 2. Comparison of the degree of airway stenosis between the two groups [n/%]

Group	Number of cases	Mild stenosis	Moderate stenosis	Severe stenosis
Experimental group	20	14(70.00)	6(30.00)	0
Control group	20	7(35.00)	10(50.00)	3(15.00)
x^2	-	4.912	1.667	3.243
P	-	0.027	0.197	0.072

3.3. Comparison of shortness of breath scores between the two groups

Before treatment, there was no difference in shortness of breath scores between the two groups ($P > 0.05$). After one month of treatment, the shortness of breath score in the experimental group was lower than that in the reference group ($P < 0.05$). The results are shown in **Table 3**.

Table 3. Comparison of shortness of breath scores between the two groups [$\bar{x}$ ±s, points]

Group	Number of cases	Before treatment	After treatment
Experimental group	20	3.05 ± 0.49	0.24 ± 0.06
Control group	20	3.01 ± 0.51	0.97 ± 0.17
t	-	0.253	18.109
P	-	0.802	< 0.001

3.4. Comparison of lung function indicators between the two groups

Before treatment, there was no difference in lung function indicators between the two groups ($P > 0.05$). After one month of treatment, the lung function indicators in the experimental group were better than those in the reference group ($P < 0.05$). The results are shown in **Table 4**.

Table 4. Comparison of lung function indicators between the two groups [$\bar{x}$ ±s]

Group	Number of cases	FEV_1(%)		VC_{max}(L)		FVC(%)	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Experimental group	20	1.58 ± 0.16	2.08 ± 0.24	1.78 ± 0.11	2.79 ± 0.32	3.05 ± 0.41	2.21 ± 0.27
Control group	20	1.60 ± 0.15	1.79 ± 0.20	1.79 ± 0.15	2.31 ± 0.28	3.08 ± 0.37	2.70 ± 0.34
t	-	0.408	4.151	0.240	5.048	0.243	5.047
P	-	0.686	< 0.001	0.811	< 0.001	0.809	< 0.001

4. Discussion

The pathogenesis of airway stenosis is related to factors such as decreased lung function or significant changes in the anatomical structure of the airways. It continuously affects the body's oxygen supply status and can induce many pathophysiological changes, leading to complications such as lung infections. Among the types of airway stenosis diseases, benign lesions are the main type, requiring early symptomatic treatment to prevent conditions such as respiratory distress syndrome [3]. Among conventional treatments, airway dilating drugs such as dexamethasone can improve the degree of stenosis and restore lung ventilation function to a certain extent.

However, long-term medication has many side effects and can easily lead to drug resistance, so the feasibility of treatment is limited. Orotracheal intubation ventilation therapy or endoscopic mucosal resection under bronchoscopic guidance are common treatments for this disease, and they have a good effect on improving airway stenosis. However, there are many complications after treatment, so it has limitations. Driven by the development of endoscopic diagnosis and treatment equipment and imaging technology, the placement of stents in the airway has become a newer therapy for this disease [4]. Based on this premise, standardized bronchoscopy intervention treatment came into being. This therapy reduces the pressure level inside the airway, prevents related symptoms such as bronchial asthma, and reduces the chance of restenosis. For benign tumors and other etiologies, interventional therapy can directly remove tumor tissue, combined with cryotherapy for systematic treatment of residual sites, ultimately achieving ideal treatment results. The operational process of interventional therapy is relatively simplified, efficient, and reliable, and does not cause significant damage to the patient's airway tissue, so the feasibility of treatment is high [5].

The results showed that the total effective rate of the experimental group was higher than that of the control group, the proportion of mild airway stenosis was higher than that of the control group, the dyspnea score was lower than that of the control group, and the lung function index was better than that of the control group ($P < 0.05$). The reason is that interventional therapy can accurately locate the stenosis site, the whole treatment process is painless, and can be repeated according to the treatment effect, so it has a strong radical cure [6]. During treatment, cryotherapy uses high-pressure gas that passes through a throttle orifice to rapidly lower pressure and generate extreme cold. This sudden temperature drop causes the targeted lesion tissue to cool quickly, leading to rapid cell necrosis. Additionally, it can result in the formation of microthrombi or induce significant reperfusion injury within the affected tissue [7].

In addition, cryotherapy can stimulate the immune system and cause a large number of diseased cells to undergo apoptosis. During cryotherapy, granulation tissue, vascular endothelium, or mucosal tissue all contain high water content, so they are more sensitive to cryopreservation. Based on this, this therapy is not easy to cause local reactions, which can make patients highly tolerant to the treatment process, so the treatment safety is better. Balloon dilation can accurately place the balloon at the site of airway stenosis, and use a high-pressure gun pump to allow the balloon to expand moderately, thereby effectively expanding the airway, which is convenient for treatment and is an ideal treatment for diseases such as tuberculous airway stenosis [8]. Argon plasma treatment can effectively transmit high-frequency electrical energy, and use ionization reaction to quickly solidify diseased tissue. The stent implantation can accurately place a stent at the location of the airway stenosis, and the expansion effect of the covered stent can be exerted for a long time, and the duration of the treatment effect is longer [9, 10].

5. Conclusion

In summary, interventional therapy can use bronchoscopy to carry out various treatment interventions such as cryotherapy, balloon dilation or high-frequency electric knife, etc., to reduce the degree of airway stenosis, reduce the accompanying dyspnea symptoms of patients, and can significantly improve the lung function of patients. Its treatment is highly effective and can be used as a standardized therapy for patients with this disease.

Disclosure statement

The authors declare no conflict of interest.

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