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Original Article

Short-term effects of respiratory function training on patients with pleural effusion undergoing closed drainage and related effects on pulmonary function

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Abstract: Objective: To explore the effects of three-ball breathing training on the pulmonary function of patients undergoing thoracic closed drainage, and analyze the associated influencing factors of compliance. Methods: Lung cancer patients (n=400) treated with thoracic closed drainage tubes were selected and were randomly grouped into the observation group and control group following a random number table, with 200 cases in each group. After operation, patients in the control group conducted routine respiratory function training and the observation group received three-ball breathing training, both for 2 months. Subsequently, operation related indices, lung function and compliance of the two groups were compared. The influencing factors of patients' compliance were analyzed by one-way Analysis of Variance (ANOVA) and binary Logistic regression analysis. Results: The observation group had more drainage volume and shorter time for drainage tubes and hospitalization than the control group (P<0.05). Compared with 1 day after operation, Forced vital capacity (FVC), peak expiratory flow (PEF), forced expiratory volume in the first second (FEV1) and FEV1/FVC of the two groups all increased in the 2 weeks following operation, and the corresponding indices of the observation group were much higher than the control group (P<0.05). Comparing to the control group, patients in the observation group had an evidently higher total compliance rate and a markedly lower partial compliance rate (both P<0.001). At last, the correlation analysis showed that patients' education level, respiratory function training methods, awareness of the disease and the degree of family assistance can all clearly affect the compliance of patients' respiratory function training (P<0.05). Conclusion: Correct and scientific respiratory function training after operation is helpful to increase the drainage flow and improve the pulmonary function of patients undergoing closed thoracic drainage. Education level, respiratory training methods, awareness of patient's condition and assistance from their families are the main factors influencing the compliance of patients.

Keywords: Respiratory function training, closed thoracic drainage, pulmonary function, compliance, influencing factors

Introduction

Clinically, about 50% of lung cancer patients may be accompanied by pleural effusion, which can further aggravate disease progression [1, 2]. Large amounts of pleural effusion can be accompanied by chest pain and chest tightness [3]. Closed thoracic drainage helps to restore the normal pulmonary function of the patients by using gravity to discharge a large amount of pleural effusion out of the body [4, 5]. After closed thoracic drainage, scientific respiratory exercise is needed to restore normal pulmonary function through expanding the atrophic lung [6]. The device of three-ball breathing training is reliable and it is especially designed for postoperative lung recovery, aiming to improve the postoperative lung capacity and enhance the patient's expectoration function. Encouraging slow deep breathing can be used for strengthening the respiratory muscle tissue, recovering and maintaining the lung volume, so as to achieve more ideal lung function recovery effects [7]. However, the application of

three-ball respiratory training in postoperative respiratory training of patients undergoing thoracic closed drainage has not yet been reported.

Materials and methods

General materials

Patients with pleural effusion (n=400) hospitalized in The First Affiliated Hospital of Qiqihar Medical College from August 2017 to August 2019, were selected and divided into the observation group and control group following a random number table, with 200 cases in each group. General materials are shown in Result 1. This study has been approved by the medical Ethics Committee of The First Affiliated Hospital of Qiqihar Medical College.

Inclusion criteria: (1) People aged 20-65 years; (2) One side lobectomy due to early and middle stage lung cancer and placed with closed drainage tube postoperatively; (3) Have signed the informed consent. Exclusion criteria: (1) Combined with pleural effusion caused by heart failure or infection and other reasons; (2) Single lung resection patients; (3) Pregnant and lactating women; (4) Patients with abnormal coagulation; (5) Patients with cognitive dysfunction, or who could not complete the questionnaire independently.

Methods

All patients underwent unilateral lobectomy and were placed with closed drainage tube after operation. Routine respiratory function training was conducted in the control group: patients were informed of correct methods of expectoration, and were instructed to learn lip retraction breathing and abdominal breathing. Lip contraction breathing uses the nose to inhale and uses the mouth to exhale, keeping the lips in the shape of contraction. Abdominal breathing keeps the abdomen bulge when inhaling and concave when exhaling. After operation, three-ball respiratory training was used in the observation group: hold the three ball breathing training device (purchased from Beijing Yongping Trading Co., Ltd. brand: Chongren Galemed, Taiwan, Model: 4311, Origin: China) with the mouth and exhale slowly to the limit. Then, inhale rapidly and forcefully continuously and try your best to keep the ball rising in the training device, and try to make the ball rise to the highest scale and maintain it for 2-3 s. Then open the mouth and slowly exhale the air from the body. After every deep breath, patients need to adjust their breathing and continue for the next practice, with 20 breathing cycles every time, and conduct the exercise every 2 hours, for six times a day. The patients in both groups were trained for 2 months continuously.

Outcome measures

Main outcome measures: (1) Drainage volume, time for bearing drainage tubes and hospitalization time were compared between the two groups. (2) Forced vital capacity (FVC), peak expiratory flow (PEF), forced expiratory volume in the first second (FEV1) and FEV1/FVC were measured at 1 day and 2 weeks postoperatively using lung function detector (purchased from Butler company, UK, Model: BTL-08 SPIRO, origin: UK).

Minor outcome measures: (1) Two months after the operation, the patients were asked to fill in the compliance questionnaire of respiratory function training [8] independently to evaluate the compliance of patients with respiratory function training, including the understanding of respiratory function training knowledge, whether the training methods were conducted in accordance with the instructions of medical staff, whether the patients performed it every day, the duration of each training and the training frequency every day. Every item was scored with 20 points, for a total of 100 points. Compliance was divided into complete compliance (90-100 points), partial compliance (60-89 points) and non-compliance (<60 points). The higher the score is, the better the compliance is. (2) Using the method of one-way Analysis of Variance (ANOVA), the influencing factors of compliance were analyzed from the aspects of patients' gender, age, education level, awareness of the disease and the degree of family assistance. Then these selected variables were further analyzed using binary logistic regression analysis, and finally the influencing factors of compliance of respiratory function training were determined. In this study, partial compliance and non-compliance were classified as poor compliance.

Table 1. Comparison of general materials (n, $\bar{x}$ ± sd)

	Observation group (n=200)	The control group (n=200)	χ^2/t	P
Gender (n)			0.823	0.364
Male	117	108		
Female	83	92		
Age (year)	45.7±5.2	46.3±6.6	1.010	0.313
BMI (kg/m^2)	21.8±1.8	22.1±2.1	1.534	0.126
Hb (g/L)	124.4±18.5	126.5±20.2	1.084	0.279
Cancer type (n)			1.862	0.394
Adenocarcinoma	137	146		
Squamous carcinoma	47	36		
Others	16	18		
Clinical stage			0.533	0.465
Early stage	132	125		
Medium stage	68	75		
Amount of pleural effusion (n)			0.344	0.558
Small amount	195	193		
Medium quantity	5	7		

Note: BMI: body mass index; Hb: hemoglobin; Small amount of pleural effusion: X-ray showed that pleural effusion was lower than hilar, and the amount of pleural effusion was less than 500 ml; Medium quantity of pleural effusion: X-ray showed that the level of pleural effusion was the same as that of hilar, and the amount of pleural effusion was about 500~1000 mL.

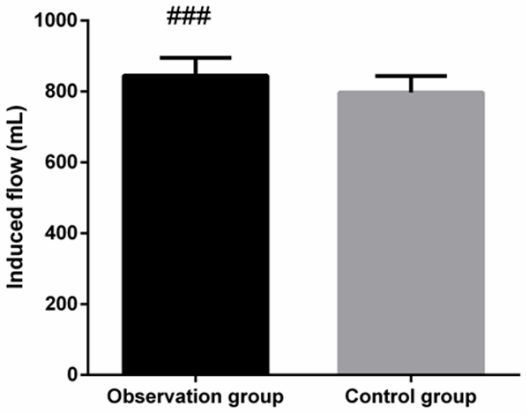

Figure 1. Comparison of drainage volume. ###P<0.001 vs Control group.

Statistical analysis

SPSS 20.0 was used for data statistics. The enumeration data was expressed in n/% and Chi square (χ^2) test was used. The measurement data was expressed in mean ± SD. Paired t-test was used for before and after self-comparison, and independent t-test was used for inter group comparison. First, one-way ANOVA was used to analyze the factors that may affect the patient's compliance, and then stepwise forwards method (Wald) was used to screen the variables, with 0.05 as the inclusion level and 0.1 as the exclusion level. Then, the variables with statistically significant differences in one-way ANOVA were taken as dependent variables, and the quality of patients' compliance was taken as independent variables. The independent risk factors affecting patients' compliance were determined by logistic regression analysis. OR value >1 indicates that this factor is an independent risk factor for patients' compliance. P<0.05 means the difference is statistically significant.

Results

Comparison of general materials

There was no significant difference in general materials between the two groups, including their gender, age, body mass index, nutritional status (calculated by hemoglobin level), cancer type, clinical stage and amount of pleural effusion (P>0.05). See **Table 1**.

Comparison of drainage volume

Drainage volume of the observation group (844.66±50.06 mL) was larger than that of the control group (796.79±46.70 mL), and the difference was statistically significant (P<0.001). See **Figure 1**.

Comparison of time with drainage tubes and hospitalization

Compared with the control group, time for bearing drainage tubes and hospitalization in the observation group were significantly shorter (P<0.05). See **Table 2**.

Comparison of lung function before and after operation

Compared with 1 day after operation, FVC, PEF, FEV1 and FEV1/FVC in the two groups were all

Table 2. Comparison of time for bearing drainage tubes and hospitalization ($\bar{x}$ ± sd)

Groups	Time for bearing drainage tubes (d)	Hospitalization time (d)
Observation group (n=200)	4.8±1.1	15.5±2.2
Control group (n=200)	5.1±1.3	18.9±2.5
t	2.491	14.439
P	0.013	<0.001

Table 3. Comparison of lung function before and after operation ($\bar{x}$ ± sd)

Groups	Observation group (n=200)	Control group (n=200)	t	P
FVC (L)				
1 d after operation	1.88±0.43	1.82±0.39	1.462	0.145
2 weeks after operation	2.12±0.51**	1.90±0.40*	4.800	<0.001
PEF (L/s)				
1 d after operation	4.54±1.10	4.61±1.27	0.589	0.556
2 weeks after operation	5.12±1.05**	4.89±0.96*	2.286	0.023
FEV1 (L)				
1 d after operation	1.20±0.44	1.13±0.37	1.722	0.086
2 weeks after operation	1.65±0.56**	1.25±0.35**	8.566	<0.001
FEV1/FVC (%)				
1 d after operation	57.68±2.34	57.74±3.20	0.214	0.831
2 weeks after operation	60.05±2.55**	58.50±2.74*	5.856	<0.001

Note: *P<0.05, **P<0.01 VS 1 d after operation. FVC: forced vital capacity; PEF: peak expiratory flow; FEV1: forced expiratory volume in the first second.

Table 4. Comparison of compliance of patients with respiratory function training (n, %)

Groups	Total compliance	Partial compliance	Non-compliance
Observation group (n=200)	92 (46.00)	72 (36.00)	36 (18.00)
Control group (n=200)	44 (22.00)	111 (55.50)	45 (22.50)
χ^2	25.668	15.321	1.254
P	<0.001	<0.001	0.263

increased significantly within 2 weeks after operation, and the growth rate of the observation group was much higher compared to the control group (P<0.05). See **Table 3**.

Comparison of compliance of patients with respiratory function training

The total compliance rate of patients in the observation group was significantly higher than that in the control group, and the partial compliance rate was significantly lower than that in the control group (P<0.001). There was no significant difference in non-compliance rate between the two groups (P>0.05). See **Table 4**.

Analysis of the influencing factors of compliance

Results of one way ANOVA showed that patients' education level, respiratory function training method, awareness of the disease and family assistance were all independent influencing factors of good compliance (P<0.05), but gender and age were not related influencing factors (P>0.05). See **Table 5**.

Logistic regression analysis

Four factors, including patients' education level, three-ball respiratory function training method, awareness of the disease and assistance of family members, were used as independent variables, and whether patients' compliance was good or not was used as dependent variables. The results showed that there was a positive correlation between the patients' education level, three-ball respiratory training method, awareness of the disease, and degree of family assistance with the compliance of patients' respiratory training (P<0.05). See **Table 6**.

Discussion

Closed thoracic drainage is one of the most common operations in thoracic surgery, it is often used for the treatment of pleural effusion [9], pneumothorax [10] and hemothorax [11]. Patients with thoracic closed drainage need auxiliary respiratory muscles to maintain blood oxygen saturation. However, improper breathing modes may have adverse effects on the

Table 5. Analysis of the influencing factors of compliance

Influencing factors	Good compliance (n=136)	Low compliance (n=264)	χ^2	P
Gender (n)			0.011	0.915
Male	77	148		
Female	59	116		
Age (year)			0.470	0.790
<30	23	49		
31~50	60	121		
>50	53	94		
Education level (n)			52.474	<0.001
Junior middle school and lower	24	144		
Senior middle school	40	54		
Bachelor degree and above	72	66		
Respiratory function training method (n)			25.668	<0.001
Routine respiratory training	44	156		
Three-ball respiratory training	92	108		
Awareness of the disease (n)			8.709	0.013
Fully informed	78	112		
Partial informed	44	106		
Ignorance	14	46		
Family assistance (n)			19.348	<0.001
Well	70	79		
Medium	45	109		
Worse	21	76		

Table 6. Logistic regression analysis

Variables	β	SE	Wald	P	OR	95% CI
Education level	2.857	0.374	8.475	0.023	2.109	1.667~3.375
Three-ball respiratory training	5.998	0.478	10.884	0.019	2.776	1.876~4.480
Awareness of the disease	4.303	0.630	8.940	0.042	2.176	1.709~3.574
Family assistance	4.409	0.362	9.770	0.037	2.361	1.990~4.461

Note: β: regression coefficient; SE: standard error; OR: odd ration; CI: confidence interval.

recovery of postoperative respiratory function, thus resulting in increased risk of pulmonary complications and declined quality of life [12].

Human lung circulation has good compensatory function. After closed thoracic drainage, active respiratory training is helpful for the prognosis of patients by promoting the recovery of lung function through the compensatory ability of the body [13, 14]. Previous study revealed that reasonable respiratory function training can enhance the contractile strength of respiratory muscles, strengthen the airway defense ability, and ultimately improve the lung function of the body [15, 16]. In this study, a three-ball respiratory training device was used to train the respiratory function of patients after thoracic closed drainage. Indexes including FVC, PEF, FEV1 and FEV1/FVC of patients in the observation group were significantly higher than those in the control group within two weeks after the operation, indicating that reasonable postoperative respiratory training is helpful to improve the pulmonary function of patients with thoracic closed drainage, which is also consistent with the results of other relevant studies [17]. The reason, may be that the three-ball breathing training device improves the training of inspiratory muscles. Through the training of inspiratory muscles, the respiratory frequency of patients is reduced but the inspiratory flow rate is increased. Besides, the

fatigue state of the patients' ventilator is effectively improved and the strength and endurance of respiratory muscles are also enhanced, thus the FVC, PEF and FEV1 of patients are further improved. In addition, compared with the control group, the observation group had a larger drainage volume, shorter time for bearing drainage tubes and hospitalization. The above results suggest that the three-ball breathing training device used after closed thoracic drainage can significantly increase the drainage effects and promote the prognosis of patients. In sum, our study confirms the importance of reasonable respiratory function training after closed thoracic drainage.

The training of respiratory function after closed thoracic drainage is very important because it helps to promote the recovery of postoperative pulmonary function. However, due to lack of respiratory function training knowledge and poor treatment compliance, some patients cannot perform the training properly, resulting in poor recovery of pulmonary function, and sometimes further serious complications and poor prognosis [18-20]. In the three-ball breathing training device, there are three colored balls distributed in different spaces. Patients can clearly observe the rise and fall of the ball, which reflect the volume of patients' breathing. This kind of training is a silent motivation for patients, which can better enhance the compliance of patients with training [21]. In this study, the complete compliance rate in the observation group was significantly higher than that in the control group. In addition, the correlation analysis showed that patients' education level, three-ball breathing training method, awareness of the disease and family assistance degree were all positively correlated with the compliance of patients with breathing training postoperatively. We conclude that patients with higher education background have deeper and more rational understanding about the disease and postoperative respiratory function training, so they may have better compliance in the process of postoperative respiratory function training. These above results also suggest that we can guide the patients to understand the importance and necessity of postoperative respiratory function training as much as possible in our future clinical work. At the same time, we can lead the patients' families to help with better assistance, so as to promote the patients' recovery as early as possible.

To sum up, reasonable postoperative respiratory function training can help to increase the postoperative drainage volume of patients with thoracic closed drainage, shorten the time for bearing drainage tubes, thus improving the pulmonary function of patients. At the same time, patients' education level, awareness of the disease and degree of family assistance are all closely associated with the compliance of patients' respiratory training.

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Disclosure of conflict of interest

None.

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