

Analysis of the advantages and disadvantages in application of oxygen-driven aerosol and aerosol inhalation by air compressor for the pediatric asthma

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Abstract: Present study is done to analyze the advantages and disadvantages in application of oxygen-driven aerosol and aerosol inhalation by air compressor for the pediatric asthma. A total of 180 patients with pediatric bronchial asthma were randomized into the oxygen-driven aerosol group (Group A, n=90) and the air compressor-driven aerosol group (Group B, n=90). Patients in both groups received 0.5 mg budesonide suspension, 0.2 mg salbutamol and 4 mL normal saline, and following the treatment, we recorded the excellence rate, improvement rate, total effectiveness rate, and the changes in oxyhemoglobin saturation (SaO₂) before and after treatment, and the remission time in two groups. In Group A, patients had a higher total effectiveness rate (95.79% vs. 75.79%) but a lower failure rate (4.21% vs. 24.21%) than those in the Group B, with statistically significant differences ($p > 0.05$). Following the aerosol inhalation, SaO₂ levels in two groups were ameliorated in comparison with the levels before treatment [Group A: (95.4±0.4) % vs. (80.6±0.8%, Group B: (92.1±1.1)% vs. (79.3±0.7)%] ($p < 0.05$), and the level in Group A following the treatment was higher than that in Group B [(95.4±0.4) % vs. (92.1±1.1)%] ($p < 0.05$). Furthermore, patients in Group A had a longer effective remission time and total remission time than those in Group B, but the differences had no statistical significance ($p > 0.05$). Both of the oxygen-driven aerosol inhalation and aerosol inhalation by air compressor can improve the clinical symptoms of pediatric asthma effectively, but oxygen-driven aerosol inhalation works more efficiently, with an elevated SaO₂. Thus, oxygen-driven aerosol inhalation is preferred in clinical practice.

Keywords: Oxygen-driven aerosol inhalation, aerosol inhalation by air compressor, pediatric asthma.

INTRODUCTION

Bronchial asthma, one of the most common chronic airway diseases in children, is mainly characterized by the recurrent cough, stridor or dyspnea, usually concomitant with the reversible bronchial hyperresponsiveness and obstructive airway diseases, severely affecting the learning, life and activity of patients; particularly, for the attack of severe asthma, delayed or inappropriate treatment may result in the death. All over the world, the prevalence of asthma has attained 1% to 18%, affecting nearly 300 million asthma patients (including adults and children), and this number has been increasing gradually (Varney *et al.*, 1991). Two national epidemiological investigations on the pediatric asthma in China show that the average prevalence of pediatric asthma has increased from 0.91% to 1.54%, with an average of increase in a decade by 64.84% (Akinbami *et al.*, 2002).

Aerosol inhalation has been used as one of the major methods in treatment of pediatric asthma for its convenience in operation, direct delivery of drug to the lesion, high concentration of drug surrounding the lesion, security and minor side or toxic effect (Walker *et al.*, 2001). Currently, aerosol inhalation is carried out mainly through two methods, oxygen-driven aerosol inhalation and aerosol inhalation by air compressor. In this study, we

compared the efficacy of these two methods on the pediatric asthma and their advantages and disadvantages, so as to provide reference for clinical application.

MATERIALS AND METHODS

Clinical data

A total of 180 patients with pediatric bronchial asthma who visited the clinic or were admitted to the hospital between January 2017 and December 2017 were enrolled in this study as the subjects, and all patients conformed to the diagnostic criteria of Chinese Pediatric Society, Chinese Medical Association, with clinical manifestations including cough, short of breath, dyspnea, wheezing rales in lung, extended respiratory phase, decrease in peak expiratory flow (PEF), onset time <3 days and short of breath within 24 h. Among these patients, there were 93 males and 87 females, with an average of (6.37±1.09) years old, and they were randomized into Group A (oxygen-driven aerosol inhalation, n=90) and Group B (aerosol inhalation by air compressor, n=90). In Group A, there were 46 males and 44 females, with an average age of (5.99±1.00) years old; in Group B, there were 47 males and 43 females, with an average age of (6.01±1.03) years old. Exclusion criteria: patients with severe hepatic or renal dysfunction; patients with the history of hormone treatment before admission; patients complicated with the respiratory failure, heart failure, or other diseases; patients

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with congenital heart disease, bronchial disease or any diseases that could induce the asthma. Comparisons of the baseline data, including age, gender and disease condition, between two groups showed no statistically significant difference ($p>0.05$), suggesting that the data were comparable.

Methods

We measured the oxyhemoglobin saturation (SaO_2) levels in all subjects and before aerosol inhalation, patients received the comprehensive treatment, including anti-inflammation, anti-asthmatic therapy, anti-tussive therapy and phlegm reduction. For patients in Group A, oxygen-driven aerosol inhalation was performed at a flow rate of oxygen at 5 to 8 mL/min for 15 to 30 min, with a mixture of 0.5 mg budesonide suspension + 2.5 mg salbutamol + 4 mL normal saline, twice per day. Patients in Group B received the same medication through aerosol inhalation by air compressor.

Observation indexes

Following 5 days of aerosol inhalation, we compared the excellence rate, improvement rate, failure rate, total effectiveness rate, changes in SaO_2 before and after treatment and the remission time between two groups.

Evaluation criteria for efficacy

Excellence: patients with significant improvement in cough and short of breath, disappearance or obvious reduction in stridor in lung. Improvement: Patients with remission in cough and short of breath, and reduction in stridor in lung. Failure: patients with no amelioration in cough or short of breath, or even exacerbation.

Ethical approval

This protocol had been approved by the Ethic Committee of the Henan children's Hospital, and all subjects had agreed to participate in the study.

STATISTICAL ANALYSIS

SPSS 19.0 software was utilized for statistical analysis. Enumeration data were presented in form of percentage and cases, and intergroup comparison was performed using chi-square test. Measurement data, in form of mean \pm standard deviation ($\bar{x} \pm s$), were compared with t test between two groups. $P<0.05$ suggested that the difference had statistical significance.

RESULTS

Comparison of the general data between two groups

Comparisons of the age, gender and disease condition between two groups showed that the differences had no statistical significance ($p>0.05$), suggesting that the data were comparable (table 1).

Comparison of the efficacy between two groups

Following 5 days of aerosol inhalation, patients in two groups had significant amelioration in asthma symptoms. In Group A, the excellence rate, improvement rate and total effectiveness rate were all higher than those in Group B, but only difference in the total effectiveness rates had statistical significance [91(95.79) vs.72 (75.79)] ($p=0.001$). In Group A, there were 4 patients with failure, taking up 4.21% of the total, while in Group B, there were 24 patients with failure, taking up 24.21% of the total, and the difference had statistical significance ($p=0.001$; table 2).

Comparison of the levels of SaO_2 before and after treatment in two groups

Following the aerosol inhalation, significant improvement was identified in the levels of SaO_2 in two groups in comparison with the levels before treatment, and the difference had statistical significance ($p<0.05$). After treatment, the increase in SaO_2 level in Group A was much higher than that in the control group ($p<0.05$; table 3).

Comparison of the remission time between two groups

Following the aerosol inhalation, patients in Group A had longer effective remission time and total remission time than Group B, but the differences showed no statistical significance (table 4).

DISCUSSION

Bronchial asthma is a kind of chronic inflammatory airway disease commonly caused by multiple cells, including eosinophilic granulocytes, mastocytes, T lymphocytes, neutrophils and airway epithelial cells, as well as the cell components. Bronchial asthma, though its pathogenesis remains unknown, is believed to be associated with the genetic factors, individual or familial allergic history (Bodtger *et al.*, 2002). As a chronic inflammation, bronchial asthma results in the airway hyper responsiveness, and the exposure to multiple stimuli gives rise to the airway obstruction and airflow limitation, thereby triggering recurrent short of breath, polypnea, chest distress or cough, and patients usually suffer from the attack of exacerbation at night or in the morning, mainly affecting the children aged between 1 and 6 years old.

Aerosol inhalation is the most efficient administration pathway for treatment of pediatric asthma (Arvidsson *et al.*, 2002), and it can deliver the highly concentrated drugs directly to the lesions through dispersing the drug and water in the air, which are then inhaled into the airway and lung. Thus, aerosol inhalation is characterized by the rapid onset, potent effect, low doses and few adverse reactions, and has been used as the preferred method in controlling the acute attack of asthma (Des Roches *et al.*,

Table 1: Comparison of the general data between two groups

Group	n	Average of age (years)	Gender (male/female)
Group A	90	5.99±1.00	46/44
Group B	90	6.01±1.03	47/43

Table 2: Comparison of the efficacy between two groups

Efficacy	Group A (n=90)		Group B (n=90)		c ²	p
	Case (n)	Effectiveness rate (%)	Case (n)	Effectiveness rate (%)		
Failure	4	4.44	22	24.44	16.406	0.000
Improvement	48	53.33	41	45.56	1.419	0.196
Excellence	38	42.23	27	30.00	2.899	0.094
Total effectiveness rate	86	95.56	68	75.56	16.406	0.000

Table 3: Comparison of the levels of SaO₂ before and after treatment in two groups ($\bar{x} \pm s$)

Group	SaO ₂ (%)	
	Before treatment	After treatment
Group A	80.7±0.9	95.5±0.5 ^{ab}
Group B	79.4±0.8	92.2±1.2 ^a

Note: ^a p<0.05 vs. the level of the same group before treatment; ^b p<0.05 vs. Group B.

Table 4: Comparison of the remission time between two groups

Group	Effective remission time (h)	Total remission time (d)
Group A	13.88±2.22	4.41±0.82
Group B	15.45±1.98	5.87±0.66

1996). At present, there are a number of atomizers, with varying size of fogdrop and different advantages and disadvantages. The size of fogdrop directly affects the delivery and accumulation of drug: Fogdrop in size between 5 and 20 mainly accumulates in the nose and throat and upper airway, while that in size between 1 and 5 mainly accumulates in the bronchiole or alveoli. Thus, rational choice of the aerosol inhalation method is key to the treatment of asthma (Grembale *et al.*, 2000). Ultrasonic aerosol inhalation generates fogdrop in a larger size, and the inhaled drug mainly accumulates in the upper airway, but scarcely in lower airway (Novembre *et al.*, 2004). Furthermore, the large quantity of liquid contributes to a decrease in the SaO₂ during aerosol inhalation, aggravating the dyspnea, which makes it more difficult for patients to cooperate with the treatment (Burrows *et al.*, 1995). Thus, it is not applicable for the treatment of bronchial asthma (Ulrik *et al.*, 1998). Aerosol inhalation by air compressor, with a low-pressure pump to provide air, can atomize the drug through a capillary jet to form fogdrop, among which fogdrop at an average size of 4.8 accounting for nearly 80% can be inhaled (Novembre *et al.*, 2004). Driven by air, the drug can be easily delivered to the bronchioles and deep lung to effectively eliminate the inflammation and edema in the deep airway and lung, so as to eradicate the bronchial spasm and ameliorate the ventilation. This is also conducive to resolving the pulmonary atelectasis caused by the phlegm

obstruction, and the prioritized method in controlling the acute attack of asthma (Burrows *et al.*, 1995).

Oxygen-driven aerosol inhalation can draw the drug solution by the negative pressure generated during the oxygen passing through the capillaries and then crash the drug into the small fogdrop, which is later delivered to the airway with the respiration of patients. Fog drop formed by oxygen-driven aerosol inhalation is in size between 2 and 4, which makes itself much easier to reach to the bronchioles and alveoli (Tobin *et al.*, 2001), so as to dilate the bronchus and mitigate the bronchial spasm. Simultaneously, aerosol inhalation can accompany the oxygen inhalation, which can better improve the anoxia due to ventilation insufficiency to alleviate the dyspnea. Thus, oxygen-driven aerosol inhalation is applicable to the treatment of patients in all ages for its definite efficacy, convenience in operation and low dose, and, thus, used as the one of the preferred methods in treatment of the acute attack of infantile asthma (Bauer CP 1993).

In this study, with the same drugs, patients in Group A received the oxygen-driven aerosol inhalation had a higher effectiveness rate than those in Group B (p=0.001), but the failure rate was significantly decreased (p=0.001), suggesting that oxygen-driven aerosol inhalation can better ameliorate the asthmatic symptoms. It is reported ^[11] that oxygen-driven aerosol inhalation can increase the level of SaO₂ in patients. The results of this study

suggested that following 5 days of treatment, SaO₂ levels in two groups were somehow increased in comparison with the levels before treatment, but the increase in Group A was more evident (p<0.05), consistent with the results of previous studies. Although the effective remission time and total remission time emerged earlier in Group A than Group B, difference showed no statistical significance, which may correlated with the small size of sample and short observation time.

Compared with the aerosol inhalation by air compressor, oxygen-driven aerosol inhalation has the following advantages: 1) Gentle and comfortable aerosol inhalation generate little stimuli and are more tolerable for infantile patients, and in this study, patients, with better compliance scarcely showed anxiety or crying during treatment; in addition, the noise, impact force and cold stimulation emerged from the aerosol inhalation by air compressor may lead to the fear, anxiety, crying or intolerance of patients. 2) Materials used in the oxygen-driven aerosol inhalation can avoid the cross contamination due to the communal use of atomizer; but the apparatus in aerosol inhalation by air compressor is used only after about half an hour of sterilization, which can hardly eliminate the risk of ward infection. 3) Oxygen-driven aerosol inhalation has a lower cost in drug atomization and treatment than the aerosol inhalation by air compression.

Despite of the convenience of oxygen-drive aerosol inhalation in clinical nursing (Varney *et al.*, 1991. Bodtger *et al.*, 2002. Burrows *et al.*,1995), physicians should also pay attention to the following notices: 1) Treatment should be performed before meal, avoiding the drug-inhalation-caused nausea or vomiting and before inhalation, secretion in mouth, nose and throat should be eliminated to keep the airway open; meanwhile, patients should be calm and nurses should minimize the tension and fear of patients. 2) Oxygen flow should be adjusted within 5 and 8L/min and excessively fast flow can damage the respiratory mucosa; atomizer should be connected after the spray of fogdrop, so as to avert the fear due to the excessive discharge of oxygen; inhalation time should be controlled within 20 min, and long-term inhalation can aggravate the bronchial edema, exacerbating the ventilation function and resulting in the ischemia and anoxia of myocardium, or even heart failure for patients in severe condition. 3) During the inhalation, physicians should monitor the reaction, changes in SaO₂ and disease condition of patients, and for any anomaly, like frequent nausea, cough, increased phlegm, chest distress, short of breath, or even dyspnea, inhalation should be immediately suspended for symptomatic treatment.

CONCLUSION

Both of the oxygen-driven aerosol inhalation and aerosol inhalation by air compressor can improve the clinical

symptoms of pediatric asthma effectively, but oxygen-driven aerosol inhalation works more efficiently, with an elevated SaO₂. Thus, oxygen-driven aerosol inhalation is preferred in clinical practice.

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