Clinical eHealth 1 (2018) 8–16

Contents lists available at ScienceDirect

Clinical eHealth

journal homepage: ww.keaipublishing.com/CEH

Chinese experts consensus for aerosol therapy assisted by Internet of Things

Dong Yang [a,1], Xixin Yan [b,1], Jian Zhou [a], Bei He [c], Chunhua Chi [d], Kunling Shen [e], Baiqiang Cai [f], Chunxue Bai [a,*]

[a] Respiratory Department, Zhongshan Hospital, Fudan University, Shanghai, China
[b] Respiratory Department, The Second Hospital of Hebei Medical University, Hebei, China
[c] Respiratory Department, Peking University Third Hospital, Beijing, China
[d] Respiratory Department, Peking University First Hospital, Beijing, China
[e] Respiratory Department, Beijing Children's Hospital, Beijing, China
[f] Respiratory Department, Peking Union Medical College Hospital, Beijing, China

ARTICLE INFO

Article history:
Received 7 November 2017
Revised 16 July 2018
Available online 27 July 2018

Keywords:
Aerosol inhalation
Indications
Therapeutic schedules
Safety
Side effects
Internet of Things

ABSTRACT

Aerosol inhalation treatment imposes direct effects on target organs with less systematic side effects and no need of deliberate cooperation of patients. However, the lack of resources and experience impairs the drug efficacy and even causes side effects. The editorial board of International Journal of Respiration reviewed the literature, discussed and summarized their experience, and finalized the Chinese experts consensus on the treatment of aerosol inhalation assisted by Internet of Things. This practice guideline was designed to guide medical staffs at all levels to carry out standardized aerosol inhalation treatment more properly.

Compared to some other administration routes, the aerosol inhalation treatment has been widely used in clinical practice for its direct effects on target organs and its advantages of fine and rapid effects, less systematic side effects and no need of deliberate cooperation of patients.[1,2] However, due to lack of resources and experience, the nonstandard problems of aerosol inhalation treatment, insufficient drug efficacy or even side effects can be found in many primary care clinics, and sometimes even in tertiary hospitals. In addition, other problems such as non-individualization, difficulty to use for critically ill patients at their homes, difficulty to measure therapeutic effects outside hospitals and delayed treatment of complications still exist. Therefore, cooperating with the professionals of pulmonary medicine and biomedical engineering, the editorial board of International Journal of Respiration developed the Chinese experts consensus on the treatment of aerosol inhalation assisted by Internet of Things, for guiding medical staffs at all levels to carry out standardized aerosol inhalation treatment more properly. And all of this will eventually speed up the realization of the future that "Context aware, reliable storage, intelligent processing and then a multiple association. Patients, professionals, general practitioners, service providers and then a mutual participation. Quality control, prevention, healthcare, diagnosis, treatment and then an emerging medical model. And a brand new model, a brand new life."

1. The indications of aerosol inhalation treatment

1. Chronic bronchitis: Use in acute exacerbation, besides infection control, antitussive, expectorant and anti-asthmatic effects, some patients with obvious wheeze or ropy sputum can also be treated.
2. Chronic obstructive pulmonary disease (COPD): For patients who are old and infirm, patients with severe condition, patients who can hardly use dry powder inhalers and patients with respiratory failure during acute exacerbation, aerosol inhalation treatment can be considered. For patients with severe condition or patients required for hospitalization, aerosol inhalation of bronchodilators, oral or intravenous use of glucocorticoids or aerosol inhalation of glucocorticoids can also be adopted.

* Corresponding author.
E-mail address: bai.chunxue@zs-hospital.sh.cn (C. Bai).
[1] Dong Yang and Xixin Yan contributed equally to this paper.

https://doi.org/10.1016/j.ceh.2018.07.001

3. Bronchial asthma (Asthma): For patients with severe condition and patients who cannot use inhalers properly, aerosol inhalation treatment can be considered. For patients during acute exacerbation, their initial therapy can be repetitive inhalation of short-acting bronchodilators or systemic use of glucocorticoids. Hospitalization rate can be significantly decreased when aerosol inhalation of bronchodilators combining with glucocorticoids is adopted.
4. Glucocorticoids-sensitive cough: cough variant asthma, eosinophilic bronchitis, allergic cough and other chronic cough diseases are known as glucocorticoids-sensitive cough because glucocorticoids treatments are effective for them. Aerosol inhalation of glucocorticoids can be considered in the case.
5. Post-infectious cough: The mechanisms of Post-infectious cough are involved in airway hyperresponsiveness induced by inflammation, mucus secretion and dysfunction of cilia clearance. Therefore, the short-term use of antitussives, antihistamines and decongestants as well as aerosol inhalation can be considered for patients with obvious symptoms. Aerosol inhalation of glucocorticoids can obtain remarkable effects especially for patients who cannot rest and work as normal due to severe coughing but have unsatisfactory responses to oral medication, or especially for patients who have hoarseness and obvious congestion and edema of throat.
6. Bronchiectasis: For patients with long existence of common multi-drug resistant bacteria of pseudomonas aeruginosa and with acute exacerbation due to recurrent infections, besides systemic use of antibiotics, aerosol inhalation of antibiotics can also be considered as the local treatment.
7. Ventilator-associated pneumonia: For patients with infection of multi-drug resistant bacteria and pan-drug resistant bacteria, basic treatment of intravenous antibiotics combining with aerosol inhalation of antibiotics can be considered for treating ventilator-associated pneumonia (VAP).
8. Pediatrics-related respiratory diseases: There are mainly asthma, post-infectious cough, mycoplasma pneumoniae pneumonia in acute phrase and in post-infectious convalescence, acute laryngotracheobronchitis, bronchopulmonary dysplasia, endotracheal intubation and post endotracheal intubation.
9. For perioperative patients who are elderly, smoking, suffering from chronic airway inflammatory diseases and are going to undergo upper abdominal or thoracic surgery, aerosol inhalation of expectorant and antiasthma in perioperative period can help to reduce the incidence of respiratory failure.

2. Devices, drugs and therapeutic schedules of aerosol inhalation treatment

2.1. Common devices of aerosol inhalation treatment

Nebulizers commonly used in clinic mainly include jet nebulizer, ultrasonic nebulizer and vibrating mesh nebulizer.

(1) Jet nebulizer: Jet nebulizer is also called blast nebulizer or compressed gas nebulizer. It consists of two parts: the compressed gas source and the nebulizer. The aerosolization effect of Jet nebulizer is based on the Venturi principle: air is forced to run through a small opening at a very high speed, which causes a kind of local negative pressure due to pressure drop. Then the local negative pressure can siphon drug solution from a container which connects to the outflow of the air. The mixture of air and drug solution will be shattered into innumerable aerosol drug particles when the mixture crashes into a baffle ahead. Ultimately, the aerosol drug particles will be inhaled by patients and thus play their treatment roles. Driven gas flow of Jet nebulizer is commonly 4–12 L/min. The size of aerosol particles and the aerosol amount per minute are influenced by gas flow of compressed gas source. Generally, drug solution adding in is 4–6 ml, solution consuming is 0.5 ml/min and time of aerosol inhalation is 5–15 min.

(2) Ultrasonic nebulizer: The crystal transducer at the bottom of nebulizer can transform the electric energy into ultrasonic sound energy. The ultrasonic sound energy can penetrate through a sound passing membrane at the bottom of nebulizer by means of vibration, which induces solution vibration in the container and then transmit it to the surface of the solution. Thus the solution will be in violent vibration and its surface tension and inertia will be destroyed, resulting in the generation and release of small aerosol drug particles which have treatment roles. Because the physical effects of ultrasonic nebulizer can destroy drug structure, ultrasonic nebulizer is generally only used for airway humidification rather than drug inhalation treatment. The shortcomings of ultrasonic nebulizer include increased risk of infection, easily excessive humidification and increased airway resistance.

(3) Vibrating mesh nebulizer: The principle is vibrating the ultrasonic vibration membrane violently, meanwhile, extruding drug solution through tiny mesh with fixed diameter, resulting in the generation and release of innumerable small aerosol drug particles.

2.2. Common drugs of aerosol inhalation treatment

2.2.1. Inhaled corticosteroids

(1) Budesonide (BUD): The pharmacological effects of BUD are based on 16α,17α-lipophilic acetyl groups and carbon 21-free hydroxyl groups. BUD has moderate lipid solubility as well as water solubility and shows quick anti-inflammatory effects for easily penetrating through the surface mucous layer and cytomembrane of airway epithelium, which is especially suitable for combining with short-acting beta2 receptor agonists (SABA) for treatment. The absolute bioavailability value of oral BUD is 11% but the first-pass elimination is up to 90%.

(2) Beclometasone Dipropionate (BDP): BDP is the first generation of synthetic local glucocorticoids. In fact, BDP is a prodrug. It will be activated and broken down by esterase and then partly transform into 17-single BDP (BMP) which is the active form and shows pharmacologic actions. BDP has lower water solubility and dissolves slowly in mucous layer of bronchial mucosa. The absolute bioavailability values of oral BDP and BMP are 13% and 26% respectively but the first-pass elimination is about 70%.

2.2.2. Bronchodilators

(1) β_2 agonists: β_2 agonists are the most commonly used bronchodilators in clinic. β_2 agonists can be grouped into short-acting β_2 agonists (SABA) and long-acting β_2 agonists (LABA) according to the difference of drug onset time and duration time. β_2 agonist used for aerosol inhalation in clinic is primarily SABA.

The common characteristics of SABA are rapid onset and short duration time, representative drugs of SABA are terbutaline and salbutamol. It is suggested that both the selectivity of terbutaline to β_2 receptor and the stabilization of terbutaline to mast cell membrane are better than salbutamol.