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Use of aerosol therapy in patients under mechanical ventilation in the ICU

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Abstract

Aerosol therapy is a form of drug administration that favors a rapid and easy absorption of the same in the respiratory tract; thus favoring great advantages in improving the health status of patients who are subjected to mechanical ventilation in the ICU. The most commonly used drugs are beta-agonist and anticholinergic bronchodilators. The use of this therapy should be used more frequently in these patients, but factors specific to the individual and the drug should be considered for its application; its use in patients with covid-19 should also be considered.

Keywords: Aerosol therapy; Mechanic ventilation; Covid-19; ICU.

1. Introduction

Aerosol therapy consists of a treatment method that allows us to administer substances in the form of an aerosol through a nebulizer through the inhaled route. The use of this helps us to achieve much higher concentrations of the substances administered in the bronchial tree at the same time that it reduces the appearance of systemic side effects [1]. There are certain factors that will determine its use, such as the size of the particles, the patient's age, the breathing pattern when inhaling and the conditions in which the lung is found [2].

Nebulizers produce aerosol particles with a size of 15 µm that can carry bacteria and viruses. The risk of transmission of infections through.

Droplet and aerosol nuclei can increase during nebulizer treatments, as a high volume of respiratory aerosols can be created that can be thrown at a distance greater than the pattern. If nebulized medications are required in invasive mechanical ventilation, it is recommended: Nebulization with a vibrating mesh ("Mesh"): the use of this type of nebulizer allows the drug to enter the mechanical ventilation system, without the need to open the circuit [3]. Decreasing the risk of contamination.

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Our study is based on a review of the literature on the use of aerosol therapy in patients undergoing mechanical ventilation.

2. Results

An aerosol is the suspension of liquid or solid particles in a gaseous medium. Inhalation therapy or aerosol therapy is the administration of an aerosol to a patient for therapeutic purposes. In other words, it consists of the administration of endotracheal medication through aerosol preparations. The administration of aerosols in patients undergoing mechanical ventilation is very common in intensive care units.

Inhalation of this therapy helps the drug penetrate deeply into the airways. It produces a certain local action and is thus absorbed by the body. Now, for the drug delivery to be adequate to the site of action in the airway (AV), this will depend on the technique used [4]. Therefore, different factors will intervene since the most appropriate device for the patient must be selected, considering his age, diagnosis, available equipment and the ventilatory modality.

Regarding the supply devices, for the administration of aerosol therapy in the patient under Mechanical Ventilation (MV), various devices can be used, using a jet-type pneumatic micronebulizer (Figure 1), a 22-mm extension tube with adapters (figure 2) or a T-piece with a safety valve (figure 3) that must be adapted to the mechanical ventilation circuit (CVM) (figure 4).

Figure 1 Micronebulizer

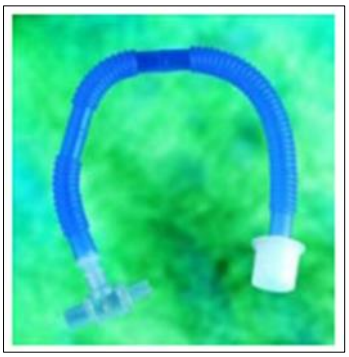

Figure 2 Extension tube

Figure 3 T-piece with valve

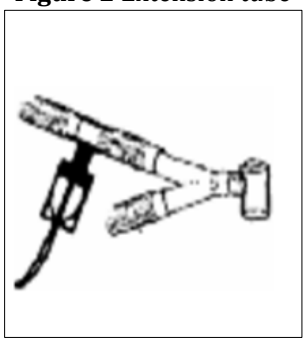

Figure 4 T-piece Adapted to CVM

Taking into account that this therapy is widely used in ICU, due to the advantages it provides over other routes of drug administration. In this, the therapeutic action of the drug begins much more quickly compared to other routes such as oral or intravenous. It has fewer side effects since, by inhaling the drugs, various problems that some anti-inflammatories or antibiotics can produce are avoided. Another advantage is that aerosol doses are generally lower than systemic doses.

Aerosol therapy delivers medications directly to the lung. Aerosol therapy has many advantages compared to systemic administration, including delivery to the lung, a faster response, and fewer systemic adverse effects.

The most commonly used application of this therapy is the administration of bronchodilator drugs that help improve the patient's condition. This therapy will be located at the extreme of easiest application, but with greater difficulty in its preparation [5] figure 5.

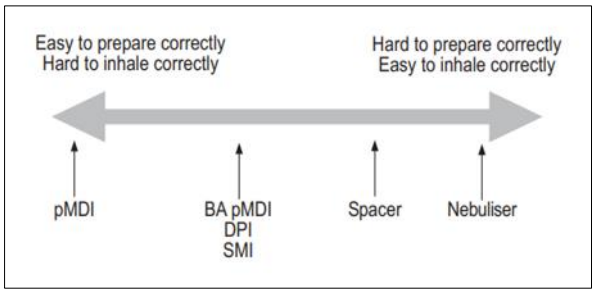

Figure 5 Graphic scale that places each device according to the ease of preparation and use

A considerable proportion of ICU patients require mechanical ventilation, as opposed to outpatients or the general unit, which introduces more factors that impact aerosol deposition, including the types of aerosol generators, the position of the generator aerosol in the ventilator circuit, mechanical ventilation settings, humidification, reservoirs, and inspiratory timing of aerosol generation.Substantial efforts have been made to understand these variables and improve the efficiency of aerosol delivery to the lungs and minimize losses, including aerosol deposition in ventilator circuits and artificial airways [6].

The complexity of aerosol therapy in ventilator-dependent patients is due to the interaction of a number of factors that determine drug deposition in the lung. New nebulizer designs that employ a vibrating plate with multiple apertures to generate aerosol and hydrofluoroalkane (HFA) propelled pMDI also significantly influence aerosol delivery during mechanical ventilation. For pMDIs to be used in ventilated patients, third-party actuator devices were required that could be connected in pressurized closed circuits. These devices range from simple adapters with a port and a single mouthpiece to more complex spacer chambers [7].

There are several factors that influence the efficiency of aerosol delivery with pMDI:

- Action time: The moment the pMDI is activated in relation to the ventilator airflow has a marked influence on the dose of medication administered.
- Priming and Shaking the Vessel: All manufacturers recommend shaking and priming the pMDI with several pulses to atmosphere before first use and after specified periods of time between uses.
- Actuator Designs: Various actuators with different designs and sizes are commercially available for the delivery of aerosolized drugs to mechanically ventilated patients.
- Placement of the pMDI in the ventilator circuit: Placement of the spacer chamber in the inspiratory limb of the ventilator circuit increases aerosol deposition with improved potential for clinical response.
- Heat and humidity: Mechanical ventilation bench models clearly established that aerosol drug delivery is reduced by up to 40% in heated / humidified ventilation circuits compared to non-humidified unheated circuits.
- Inhaled gas density: High inspiratory flow during mechanical ventilation produces transitional and turbulent flows in the narrow airways that cause the aerosol to impact the ventilator circuit and artificial airways.

PMDIs offer a safe and effective method of delivering medications to the lungs of patients requiring mechanical ventilation. If prescription drugs are available in this dosage form and a standard dose provides the desired clinical response, then pMDI is an excellent option. Careful attention to delivery details, such as the timing of activation, the actuators used, and the location of the device in the ventilator circuit, is required to optimize therapy [8].

3. Medicines most used in aerosol therapy

The most widely used medications are bronchodilators, these allow us to open the airway. Within the group of the most used bronchodilators we have salbutamol, albuterol, albuterol / salbutamol, salmeterol, and ipratropium. One of the advantages of this therapy used is that what aerosol bronchodilators do is that they start their action more quickly and, as we mentioned earlier, fewer side effects since small doses are required for them to reach the therapeutic concentration in the wall of the airway [9]

Inhaled steroids include dexamethasone and fluticasone. Some anti-inflammatories help with the inflammation that occurs in the airway, these are used in the form of aerosols and medications such as antibiotics that allow us to reduce the infection.

Suggested antibiotics to be used as aerosols are Amikacin, Gentamicin, Vancomycin, Fosfomycin, and Colistin. In table 1 of the inhaled medications used in this therapy [10].

Table 1 Inhaled drugs used during mechanical ventilation

Inhaled drugs used during mechanical ventilation
Bronchodilator
Beta-agonist (albuterol, terbutaline, metaproteronol, fenoterol)
Anticholinergic (ipratropium bromide): Combination of beta-agonist and anticholinergic (albuterol sulfate + ipratropium bromide) and Combination of long-acting and inhaled beta-agonists corticosteroid (salmeterol + fluticasone; formoterol + budesonide)
Prostaglandins
Mucoactive agents
Dornase alpha
SurfactantAntibióticos
Antibacterial
Antibiotic
Antifungal
Corticosteroids (beclomethasone; budesonide, fluticasone)
Anticoagulants (heparin)

Within the therapeutic and diagnostic indications to administer medications in aerosol form, it is very common in some respiratory diseases such as bronchial asthma, COPD, patients with pulmonary or cystic fibrosis, in oncological processes and even in patients with lung infections or upper respiratory tract already sea, for a noxa or whose respect for viruses, bacteria and fungi.

We have a drug which is Dornase alfa that is used in patients with cystic fibrosis. Other cases such as surfactant to treat hyaline membrane syndrome in the newborn and respiratory distress syndrome in adults [10].

4. Disadvantages compared to inhalation therapy

- There may be bacterial contamination either, by the device due to cleaning and disinfection between some administered doses. Therefore, this will increase the risk of infection in patients with chronic respiratory diseases.
- The people who are caregivers or the personnel in charge of the nebulized treatment are at risk of infection due to the inhalation of pathogens that are dispersed by the aerosols which are generated by the patient receiving treatment.
- Existence of a malfunction or, either, an inadequate handling with respect to the dose. That is, it can be an overdose or a low dose.
- Although the side effects are less than in other therapies, we are not exempt from these, so a frequent evaluation of these is necessary.

5. Aerosol therapy in patients with covid-19

The current pandemic of COVID-19 cases calls for increased infection control precautions. Critical patients undergoing mechanical ventilation often demand the administration of inhaled medications, this procedure requires the disconnection of the ventilatory circuit, causing aerosolization to the environment and increasing the risk of contamination to the personnel. Nebulizers generate aerosol particles of 1-5 μm capable of transporting bacteria and viruses, the risk of transmission of infection through this mechanism derives from the generation of high volume aerosols that can be propelled to a distance greater than the involved in the natural dispersal pattern [11].

To guarantee an effective administration of the inhaled medicine and to minimize the risk of contagion, it is recommended:

- Avoid opening the circuit for the use of aerosol drugs.
- The use of "jet" nebulizer is not recommended due to its poor deposit, opening of the circuit and high rate of aerosolization to the environment.
- Prefer the use of a metered dose inhaler (MDI, colloquially "puff") for all inhaled drugs.
- Any maneuver to disconnect the circuit to place the spacer, filter or other element must be performed using the clamping technique of the endotracheal tube with Rochester forceps and placing the ventilator on stand-by to avoid aerosolization.
- Non-collapsible spacers, collapsible spacers and in-line adapters are mentioned among the recommended devices. See figure 10.

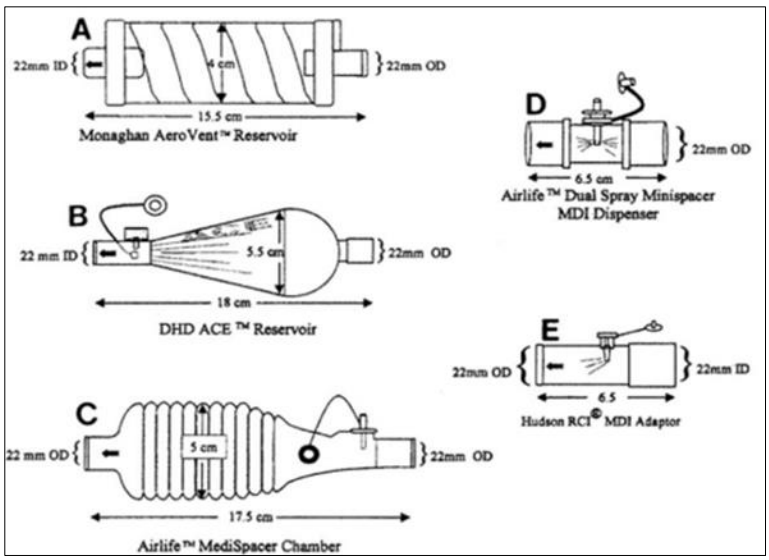

Figure 6 Spacers to deliver inhaled medications in mechanical ventilation

Avoid if possible in all patients during the epidemic situation. It is the largest source of aerosols. If necessary, use MDI device (medium dose inhaler) and spacer chamber in negative pressure room. During mechanical ventilation, use a vibrating mesh system (aeroneb®) versus a jet system, in order to avoid disconnection of nozzles. The inspiratory limb cup should be placed between the patient and the high-efficiency filter [12].

6. Discussion

In past decades, there was a widely prevalent view that aerosol therapies were unlikely to be successful in mechanically ventilated patients due to the extremely low efficiency of drug delivery in this setting. Many barriers, especially the inability of drug particles to negotiate the ventilator circuit and endotracheal tube, were thought to impede the effective delivery of aerosols to ventilated patients, and this view was supported by landmark studies that corroborated the low pulmonary deposition of aerosol drugs in this patient population compared to non-intubated outpatients. In the past, poor efficiency of aerosol generating devices in ventilation circuits, inadequate understanding of the factors influencing aerosol delivery during mechanical ventilation, and older generation mechanical ventilators that were not designed for use of aerosols posed major impediments to effective drug delivery [12].

7. Conclusion

Finally, the use of aerosol therapy in patients undergoing mechanical ventilation in the ICU is an effective, rapid, and generally without adverse effect route, which facilitates the administration of medications through the inhaled route. However, it is important to bear in mind that the application of this therapy is subject to various factors specific to the patient such as age and conditions, as well as the size of the inhaled particles, the density of the inhaled gas, the drug and its actuation time, and the device used.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflicts of interest.

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