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Ventilator circuit leak alarm—think of unusual cause

Critically ill patients, who develop ventilator-associated tracheobronchitis or pneumonia during prolonged mechanical ventilation, often require antimicrobial agents administered through the endotracheal or the tracheotomy tube. The delivery of inhaled/aerosolized antibiotics, to these patients, has some advantages when compared to systemic administration [1] using a nebulizer in the ventilator circuit but its regular use requires specific considerations to prevent malfunctioning of the ventilator which is the aim of this study.

Here, we are reporting a case where a mechanically ventilated patient developed pneumonia in the ICU and was nebulized with antibiotic colistin and polymixin B with a jet nebulizer. After 2 hours of nebulization the ventilator started showing a high circuit leak alarm as the tidal volume was not being delivered. Both inspiratory and expiratory limbs of the ventilator were checked for leak and intactness. No cracks were observed. The tubings of the ventilator were changed but the alarm still continued. We then took off the nebulizer and found powder in the form of an antibiotic deposited all over the wall of nebulizer and expiratory port attached to the ventilator. Both were removed and cleaned with warm water, dried and then attached again. To our surprise the leak alarm went off and the ventilator start working again. Meanwhile the patient was ventilated with an AMBU Bag and connected to another ventilator in the ICU. The patient was cured of ventilator associated pneumonia, extubated and discharged from the ICU after 7 days. Antibiotic nebulization played an important role in treating this condition.

Nebulized drug administration is mainly conducted by means of three types of nebulizer systems; ultrasonic, jet and vibrating mesh—aperture plate.

Here we used a **Jet nebulizer**, which is powered by compressed air or oxygen over a reservoir of liquid and sheared it into aerosol. Drug vapor is generated when compressed gas is passed through a small hole to an adjacent reservoir containing the antibiotic solution (Fig. 1) connected to the inspiratory limb of the ventilator circuit. The main advantages of jet nebulizers are the low cost and low requirements of special equipment and disposability. On the contrary, the main disadvantage of jet nebulizers is the inability of generating an optimum particle size and the prolonged duration of nebulization to administer a specific dose.

Ultrasonic nebulizers produce an aerosol from the shear force created by a vibrating piezoelectric crystal. Nebulizer output is affected by the source and flow of gas used to carry the aerosol. The main characteristics are a quiet operation, higher mean output and shorter administration times. On the contrary, they have some major drawbacks, such as cost, maintenance problems, nebulization of solvent rather than active drug deposition of solution on canister walls, need to clean the unit after each use, and possible denaturation of active molecules during aerosolization.

Vibrating mesh nebulizers, which use a micropump technology for aerosol production, have the best efficacy of 40–60% and can minimize drug wasting by synchronizing delivery of the drug to inspiration [2]. The particle size of inhaled antibiotics can be adjusted by changing the diameter of tapered holes on the plate. The main advantages include stable temperature of the antibiotic solution during nebulization and minimum risk of proteins' denaturation. This device can be used in many types of ventilators without changing the settings and has been touted to provide advantages over traditional pneumatic or ultrasonic nebulizer delivery.

The efficacy of aerosolized antibiotics depends upon 6 factors:

(1) The size of the aerosol particle should be kept between 1 and 3u. [3]. Particles of >5 u are unable to reach peripheral airways and are deposited in the main airways, whereas particles of <0.5u are too light and will exit the respiratory system along with expired gases.
(2) Air flow should be laminar during inhalation of antibiotics, and asynchrony should be minimized to minimize extrapulmonary deposition on such places as respiratory ventilation tubing, the tracheal tube, the expiratory filter.
(3) Specific ventilator settings should be selected (e.g. volume-controlled mode with a long inspiratory time and an end-inspiratory pause) to avoid flow turbulence.
(4) Nebulized antibiotics must be stable and have a relatively physiologic pH and should not provoke bronchoconstriction (cough and wheezing).
(5) A heat and moisture exchanger and/or conventional heated humidifier should be stopped during the nebulization period to avoid a massive loss of aerosolized particles through trapping and condensation.
(6) Filters should be placed between the ventilator and the inspiratory and expiratory ports and changed in between to protect the ventilator from the effects of deposited aerosol [4].

The efficacy of an aerosolized antimicrobial agent can be affected by the delivery system and the interaction of the substance with the inhaled agent [5] and it may lead to precipitation if not used for some time.

So, apart from other causes of ventilator leak cleaning of the jet nebulizer connected to the ventilator must be taken into consideration. Nebulizers used in ventilator circuits should, not be left permanently in-line and should be cleaned and changed in between nebulizations to avoid small particle bacterial aerosols. Deposition of the micro-particles in a nebulizer may lead to

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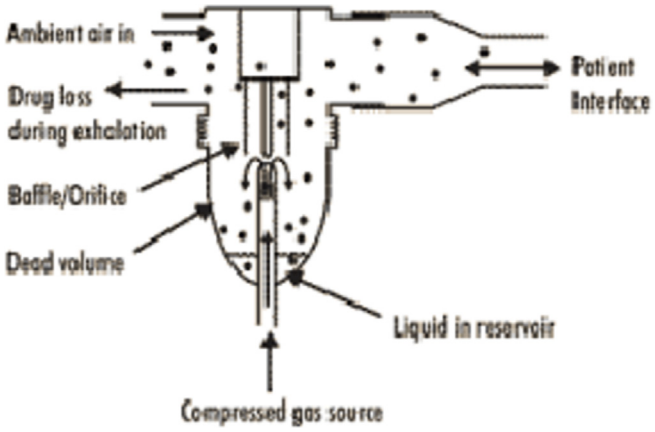

Fig. 1. Functioning of pncumatic jet nebulizer.

ventilator malfunctioning. If these technical requirements are not followed, there is a high risk of treatment failure and adverse events in mechanically ventilated patients receiving nebulized antibiotics for pneumonia [6].

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