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 Roundtable

Medication Administration/Aerosol Therapy

Tim Op't Holt, EdD, RRT, AE-C, and Karen L. Gregory, DNP, APRN, CNS, RRT, AE-C

Each issue, we ask different clinicians a set of questions about an aspect of their practice or a specific problem or condition they encounter. This month's topic is Medication Administration/Aerosol Therapy. Our participants are Tim Op't Holt, EdD, RRT, AE-C, professor of cardiorespiratory care, University of South Alabama, Mobile, Alabama; Karen L. Gregory, DNP, APRN, CNS, RRT, AE-C, FAARC, advanced practice nurse and assistant professor, Oklahoma Allergy and Asthma Clinic, Oklahoma City, and Georgetown University, Washington, DC.

1. What affects the duration/length of nebulizer treatments?

Op't Holt: Factors affecting nebulizer function include the design of the nebulizer, the gas source, and characteristics of the drug formulation. The design of the nebulizer affects nebulizer function in relation to the presence of baffles, fill volume, residual drug volume, nebulizer position, continuous versus intermittent nebulization, reservoirs and extensions, vents, valves and gas entrainment, and tolerances in manufacturing within lots. Nebulization time increases with the presence of baffles, as fill volume increases, as residual volume (volume left in the nebulizer at sputter) increases, when the nebulizer is held upright, and in intermittent nebulization. In the home, nebulizer treatments are given with an air compressor. Gas pressure and flow affect particle size and aerosol output. As gas pressure increases, particle size decreases, so the treatment is longer. A nebulizer that produces a mass median aerodynamic diameter (MMAD) of 2.5 μm when driven by a gas source of 50 psi at 6 to 10 liters per minute may produce an MMAD of $>5 \mu\text{m}$ when operated on a home compressor developing 10 psi. Particles $>5 \mu\text{m}$ are unlikely to reach the small airways, thereby decreasing therapeutic effectiveness. Nebulizers for home care should be matched to the compressor according to data supplied by the manufacturer so that the combination of specific equipment performs efficient nebulization of the desired medication prescribed for the patient.¹ Failure to clean the nebulizer appropriately can lead to degradation of performance because of clogging of the Venturi orifice, reducing the output flow. Part of patient

teaching by the asthma educator should be effective nebulizer cleaning techniques, as detailed in the resources listed in Question 5 below. Drug characteristics that affect treatment duration include drug viscosity and density; however, these factors are not likely to be variable given a fixed prescription. Given all these factors, the clinician and patient must be sure that treatments are effective, based on the goals of therapy. If therapy is ineffective, the factors listed above should be reconsidered in changing equipment or technique.

Gregory: Nebulization converts the suspension of drug into an aerosol that can be deposited into the lung. The duration of the nebulized treatment varies with diluent volume, model of nebulizer, and source of operating flow. Treatment times generally range from 5 to 20 minutes, with a mean time of 7 minutes. The greater the volume of drug and the lower the flow rate, the longer the nebulization time. The volume of medication generally ranges from 0.5 to 2.5 mL. Increasing the volume of medication and saline allows a greater proportion of the medication to be nebulized but affects the length of treatment time. A less than optimal nebulization technique can result in decreased drug delivery, potentially reduced efficacy, and alter length of time. An important component for the asthma educator to remember is the longer the nebulization time, the less likely it is that the patient will consistently take deep breaths to allow maximal aerosol delivery to the lower respiratory tract.

2. What recommendations do you have for parents of toddlers who have been prescribed nebulizer therapy?

Op't Holt: Delivery of a medicated aerosol treatment to a toddler should be through a close-fitting mask when the child is sitting calmly. The blow-by technique should not be used, as no medication is delivered by the blow-by technique. Parents can make a game out of it, or put the mask on a favorite stuffed animal, in preparation for holding the mask on the child. I know this sounds like wishful thinking, but there is no sense in fighting with a child to take the treatment if all it results

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in is holding the mask near the mouth, resulting in no drug deposition. Likewise, do not attempt to administer an aerosol treatment to a crying child. During crying, expiration is much longer than inspiration, resulting in little or no drug delivery.

Gregory: Delivery of aerosolized medication is an essential component of treatment and management in children with asthma. Parents must understand toddlers have unique characteristics that can affect adequate nebulization therapy. Pediatric anatomic and physiological differences in respiratory symptoms, such as a narrowed airway diameter compared with the adult lung, can significantly influence deposition of drug. Toddlers have a faster respiratory rate, causing a greater anatomic dead space. They also have smaller tidal volume, which makes correct technique imperative.

Emotional factors unique to this age group can present significant challenges for aerosol delivery. Many parents assume drug deposition is increased when the child is crying. The literature clearly shows crying dramatically decreases the amount of medication delivered to the lungs. Crying is a prolonged exhalation with an extremely short and fast inhalation, which prohibits a therapeutic response.

The most effective inhalation technique allowing adequate penetration into the airways is a deep inhalation with a slow inspiratory flow to decrease turbulent flow. A breath-hold following a deep inhalation allows the medication to settle on the airway. Because of the toddlers' inability to breath-hold and coordinate inspiration, toddlers require an appropriately fitted face mask with an adequate seal. Parents must recognize their toddler may be frightened of the facemask, which can generally be overcome by playing games or other measures to distract the child during the treatment time. A "blow-by" technique, which is holding a mask or open tube near the child's mouth and nose, is unacceptable for achieving a therapeutic nebulized treatment.

A major problem in asthma management is that health care professionals often do not spend adequate time educating patients regarding proper medication administration. I strongly recommend parents consult an asthma educator who can provide evidence-based asthma education and disease management. Parents must insist they be taught how to correctly administer nebulization treatments. Educational components must include the therapeutic modalities of the appropriate medical treatment regimen and cleaning and maintenance of the equipment. Parents must be able to identify signs and symptoms of worsening asthma and know when to administer nebulized therapy. Asthma educators who provide appropriate education of the child's medication regimen and devices to parents of children with asthma will hopefully decrease the risk of misuse and improve clinical outcomes.

3. What is the latest recommendation regarding open- versus closed-mouth technique for MDI therapy?

Op't Holt: Metered dose inhalers (MDIs) with the hydrofluoroalkane (HFA) propellant should be taken using the

closed-mouth technique, with a long, slow deep breath and breath-hold. What remaining chlorofluorocarbon (CFC) inhalers there are should be taken with the open-mouth technique.

Gregory: Discrepancies between open- and closed-mouth techniques are present in the literature, especially in terms of bronchodilatation. Package inserts instruct patients to use the closed-mouth technique making certain the lips are tightly around the mouthpiece of the inhaler. Some studies reveal that holding the inhaler 1 to 2 inches away from the mouth allows less medication to be deposited on the oropharynx, more peripheral lung delivery, and better pulmonary function responses over a period of time. Open-mouth technique has not consistently been demonstrated to improve clinical outcomes compared with the closed-mouth technique. Hydrofluoroalkane (HFA)-based metered dose inhalers (MDIs) require the closed-mouth technique (or a valved holding chamber) due to the HFA formulation.

Patients may find the closed-mouth technique easier especially if they experience lack of coordination between inspiration and actuating the MDI. Optimal actuation requires a 30 liter per minute inspiratory flow rate or 3 to 5 seconds deep inhalation, followed by a 10-second breath-hold. I have found for some patients the medication may be actuated on the face rather than in the mouth. Patients sometimes become frustrated with coordinating actuation and appropriate timing of the correct inspiratory flow rate with open and closed techniques.

4. What is the latest recommendation regarding spacer/holding chamber use with HFA inhalers?

Op't Holt: A valved holding chamber (VHC) should be used by patients who cannot properly use an MDI by itself, regardless of the drug. I continue to provide a VHC to patients who use inhaled corticosteroid MDIs, to prevent accumulation of inhaled corticosteroid in the oropharynx.

Gregory: The role of using spacers or valved holding chambers (VHCs) with HFA-based MDIs in asthma therapy remains controversial. The American Thoracic Society recommends a spacer or VHC be used with all MDIs to increase medication deposition. If a VHC is not available, the closed-mouth technique is used. Many health care professionals agree using a VHC decreases oropharyngeal deposition and improves medication delivery to lungs, whereas others prefer the closed-mouth technique. Package inserts for HFA-based MDIs recommend using the closed-mouth technique.

Particle sizes of drug between 2 and 5 μm diameter reach the lower airways whereas the larger particles are deposited in the oropharynx. The HFA propellant produces an aerosol with smaller particle size, resulting in improved deposition in the small airways and greater efficacy at equivalent doses compared with CFC MDIs. The purpose of spacers or VHCs is to slow down the aerosolized medication before it reaches the mouth, allowing for better deposition. The spacer or VHC prevents medication from being deposited on tongue

and throat, swallowed and delivered to systemic circulation via stomach and reduces risk of *Candidiasis* from inhaled corticosteroids.

Drug delivery from the VHC or spacer devices depends on the patient's inhalation technique. The improper use of holding chambers, such as waiting too long between MDI actuation inhalation or placing multiple puffs in the chamber before inhalation, can actually reduce drug delivery to the lungs. The literature shows VHCs increase the distance and space between the nozzle and mouthpiece of the MDI and the patient's oropharynx, allowing the relatively large particles emitted from the nozzle to evaporate and reduce in size, reducing oropharyngeal deposition by up to 90%. The VHC can help patients in achieving an appropriate flow rate of approximately 30 liters per minute.

As a reminder, the HFA inhalers must be cleaned on a regular basis to prevent medication build up and blockages. Most manufacturers recommend cleaning the mouthpiece at least once per week. Expert Panel Report-3 recommends valved holding chambers over spacers.

5. *What educational resources are available for asthma educators regarding medication administration/aerosol therapy?*

Op't Holt:

- a. *AAE Medication Inhalation Therapy: A Comprehensive Guide for Asthma Educators*. Association of Asthma Educators, 2008. A DVD of techniques, an illustrated manual, and sample instructional handouts.
- b. *A Guide to Aerosol Delivery Devices for Respiratory Therapists*. 2nd ed. American Association for Respiratory Care. http://www.aarc.org/education/aerosol_devices/index.asp

This guide is available in an edition for nurses and doctors and another for patients, and it is also available translated into numerous languages.

Gregory:

The Association of Asthma Educators' *Medication Inhalation Therapy: A Comprehensive Guide for Asthma Educators* features a comprehensive guide for inhalation therapy and device demonstration that is specifically designed for healthcare professionals.

Association of Asthma Educators (www.asthmaeducators.org/)

American Association for Respiratory Care (www.aarc.org)

American Academy of Allergy, Asthma, and Immunology

(www.aaaai.org)

American College of Allergy, Asthma, and Immunology (www.acaai.org)

American College of Chest Physicians (www.chestnet.org/accp/patient-guides/patient-instructions-inhaled-devices-english-and-spanish)

American Lung Association (www.lungusa.org/lung-disease/asthma/living-with-asthma/making-treatment-decisions/asthma-medicines.html)

Asthma and Allergy Foundation of America (www.aafa.org/)

Centers for Disease Control and Prevention (www.cdc.gov/ASTHMA/)

Authors' Note

The authors wish to state that both the authors had equal participation in the preparation and writing of this article.

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