Mastering the Metered-Dose Inhaler : An Essential Step Toward Improving Asthma Control in School

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An Essential Step Toward Improving Asthma Control in School

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School nurses can have significant cohorts of students with asthma. Effectively managing asthma in school can be challenging in terms of time, resources, and outcomes. A valuable focus for the school nurse is inhaled medication administration. Understanding the details required for optimal inhalation technique with metered-dose inhalers is the foundation for developing the skills to deliver and teach this vital aspect of asthma management. The school nurse can play a pivotal role in the partnership of asthma education that can benefit the student in school and at home.

Keywords: asthma; evidence-based practice; HFA inhalers; MDI; spacer

Every school nurse has to manage a cohort of students with asthma. The national average of school-age children with asthma is 10% (American Lung Association, 2010). Asthma rates can be higher in urban and rural areas, which equates to even larger numbers of students with asthma, making their management a daunting task for any one school nurse. Compounding this challenge is the subgroup of students whose asthma is particularly complicated and difficult to control. School nurses often have limited time and resources to address these challenges. Effective asthma management is more likely to occur when the school nurse, family, and health care provider primarily responsible for that student's asthma communicate and prioritize key aspects of the student's asthma plan. One key aspect for the school nurse to oversee is medication administration, and the type of medication most common for school nurses to administer is inhaled bronchodilators (quick-relief or rescue medication).

Bronchodilator administration by metered-dose inhaler (MDI) has become the preferred method in most settings. Upon establishing proficiency with the use of an MDI, the school nurse is then in a position to support the recommendations of Expert Panel Report 3 (EPR-3) that patient education should occur at all points of care and to teach and reinforce inhaler technique at every opportunity (National Heart, Lung, and Blood Institute [NHLBI], 2007). This is an especially appropriate use of a school nurse's time and skills, as it helps students learn a vital aspect of their asthma management that can be applied not only at school but also at home.

Inhaled Bronchodilators

The bronchodilators commonly used in school are referred to as *short-acting B2-agonists* (SABAs). They are the recommended treatment for acute asthma symptoms (cough, chest tightness, and wheeze) and for preventing exercise-induced bronchospasm, and they need to be readily accessible to students. Common side effects are nervousness, tremor, tachycardia, headache, and dizziness. Inhaled bronchodilators have an onset of action of 3 to 5 minutes and peak over 15 to 60 minutes. This peak time frame needs to be considered when reassessing for treatment of acute symptoms and for allowing adequate time when used preventively before exercise. The duration of action is 4 to 6 hours per dose; however, that duration may be shortened during exertional exercise (Houglum, 2000). MDIs should be stored at room temperature (59 °F to 86 °F).

Since asthma is primarily characterized by chronic inflammation compounded by bronchoconstriction, airway hyperresponsiveness, and mucous production, SABAs only work on one aspect of asthma, relaxing bronchial smooth muscle, thereby increasing the space for air flow. Since airway space is also dependent on inflammation and mucous production, the effect of SABAs can be variable, depending on a number of factors, including underlying lung function, trigger exposure, and overall asthma control. Even optimal bronchodilator administration will result in limited improvement of a severely inflamed airway (see Figure 1), making accurate reassessment after treatment of acute asthma symptoms such a vital aspect of the school nurse role.

Albuterol is the generic form of the oldest and most common SABA. The

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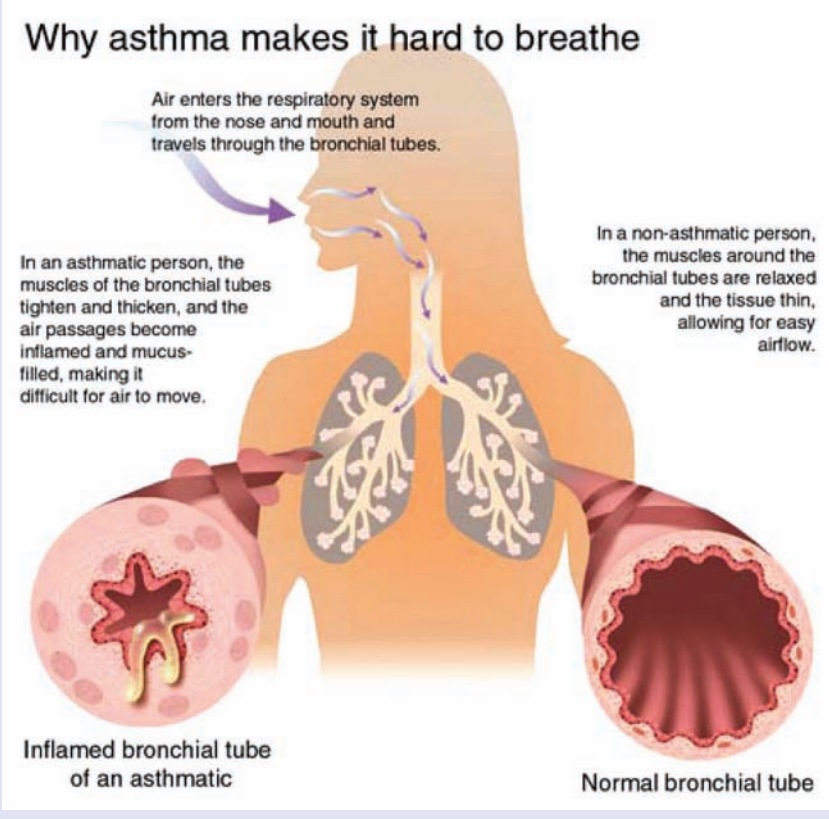
Figure 1. The Effect of Asthma on the Airways



Source: American Academy of Allergy, Asthma and Immunology.

Table 1. Advantages and Disadvantages of Metered-Dose Inhalers

Advantages	Disadvantages
Convenient, compact, and portable	Actuation technique can vary between devices and brands
Multidose capability; short treatment time	Inhalation technique can vary between devices and brands
Deposit effective doses of medication directly into the airway (target organ)	Suboptimal technique results in decreased drug lung deposition and reduced efficacy
Minimize systemic pharmacokinetic factors and adverse effects	Can be difficult to count remaining doses

three most common brands of albuterol are ProAir HFA®, Ventolin HFA®, and Proventil HFA®. Levalbuterol (Xopenex HFA®) was first approved by the U.S. Food and Drug Administration (FDA) in 1999 and differs from albuterol in that it lacks the (S) isomer that was theorized to contribute to adverse effects. Studies have indicated that levalbuterol works as well as albuterol; however, no difference in adverse effects has been demonstrated to justify its greater cost (Qureshi, Zaritsky, Welch, Meadows, & Burke, 2005). Pirbuterol is the generic medication in Maxair®, which is a unique breath-activated inhalation device. Maxair is the least common SABA used in school, is not recommended for use in children younger than 12 years, and does not have FDA approval past 2013. This breath-activated device can make it difficult to determine if an adequate actuation of medication has been administered.

The Metered-Dose Inhaler

Unlike an oral medication, inhaled medication requires lung deposition, which requires a specific learned technique. The goals of all inhaled medication are to maximize a consistent amount of intended dose that reaches the lung and to minimize the amount of medication wasted in the air or left in the mouth or throat, resulting in optimal efficacy and ability to assess dose response. No method of medication inhalation can deliver 100% of a dose into the lung; however, consistency with optimal technique is essential for achieving and assessing efficacy. An often overlooked concept in assessing asthma control is determining if inhaled medication is adequately getting into the lung before concluding that the medicine may not be working, that higher dosages are indicated, or that additional medication is necessary. Mastery of this technique is an essential step in improving asthma control. The MDI is a unique form of medication administration and requires specific knowledge and skill acquisition. Table 1 lists the advantages and disadvantages of MDIs.

The MDI is a small pressurized metal canister filled with asthma medication that is suspended in a propellant. When the canister is pushed down in its plastic holder, a dose of medication is actuated ("puffed") out. Each puff contains a dose of medication that is transported through the air by a propellant. As of 2008, the propellant used in MDIs was changed from the ozone-depleting chlorofluorocarbons (CFC) to hydrofluoroalkanes (HFA), which are ozone safe, hence the designation of HFA after the brand name of each medication that comes as an MDI. This change to HFA for MDIs has specific

Table 2. Bronchodilator (quick-relief or rescue) Metered-Dose Inhaler (MDI) Hydrofluoroalkanes (HFA) Medications

Brand Name (generic name)	Number of Doses in Canister	Priming	Comments
ProAir HFA (albuterol)	200	Before first dose: 3 sprays After 2 weeks of nonuse: 3 sprays	
Proventil HFA (albuterol)	200	Before first dose: 4 sprays After 2 weeks of nonuse: 4 sprays	
Ventolin HFA (albuterol)	200 (dose counter on MDI)	Before first dose: 4 sprays After 2 weeks of nonuse: 4 sprays When dropped: 4 sprays After washing: 1 spray	Replace when counter gets to 000 or 6 months after opening package, whichever comes first
Xopenex HFA (levalbuterol)	200	Before first dose: 4 sprays After 3 days of nonuse: 4 sprays	

clinical implications. Overall, compared to CFC, MDIs with HFA deliver a softer, warmer spray (a brand name for CFC is FREON). One surprising advantage to using HFA has been greater potential lung deposition, especially in the small airways, due to the smaller particle size of the propellant (Rau, 2005). However, one notable disadvantage is the increased variability of actuation between brands of medication. This variability is why it is important to know the specific recommendations for priming and cleaning each brand of medicine that comes as an MDI. This variability can also affect lung deposition, which explains why some brands of medication work better for some individuals. Unfortunately, MDIs with HFA are also more costly since they are not yet available in generic preparations.

Priming the MDI means spraying one or more puffs into the air in order to ensure that the puff being inhaled contains the intended dose of medication (see Table 2). An important nursing consideration is that these priming and cleaning procedures are guidelines provided by the manufacturer. These procedures should be repeated any time there is doubt that an actuation results in an appropriate spray that is typical for that brand of medication (see Table 3 for cleaning steps). It is helpful to become familiar with the physical appearance of how a specific brand of MDI sprays.

Table 3. How to Clean a Metered-Dose Inhaler (MDI)

1. Take the metal canister out of the plastic case.
2. Wash the plastic case weekly, running water through the case.
3. Shake off excess water.
4. Air dry.
5. Put the plastic case and metal canister together when **completely dry**.

Note: Cleaning instructions are the same for all medications listed in Table 2.

Many studies have demonstrated that, despite instruction, MDI inhalation technique proficiency is low among children and adolescents (Kamps, van Ewijk, Roorda, & Brand, 2000; Ozkaya, Samanci, & Guler, 2010). Studies have also demonstrated a lack of health care provider knowledge of inhalation device use (Dolovich et al., 2005). These concerns were further exemplified in a recent study of provider demonstration and assessment of inhalation technique (Sleath et al., 2011). Only 8.1% of 270 children ages 8 to 16 years were able

to demonstrate all the proper steps for using their MDIs. In addition, the 35 primary care providers in this study asked only 5.4% of these children to demonstrate their MDI technique, and only 3.8% of providers actually demonstrated the technique for their patients. This study further highlights the essential role the school nurse can have as a partner in asthma care.

The most significant clinical implication of MDI technique is oropharyngeal medication deposition, which increases side effect potential and decreases lung deposition. Factors to consider with MDI technique proficiency include:

- Fine-motor coordination
- Developmental ability to perform the sequence of skills
- Priming and cleansing of device
- Timing of MDI actuation related to inspiration
- Rate and timing of inhalation following actuation
- Use of a valved holding chamber (VHC) spacer

The classic 1981 study (by Newman, Pavia, Moren, Sheahan, & Clark) demonstrated that 80% of MDI medication was lost in the oropharynx. Studies such as these prompted the evolution of spacers and VHCs. The use of an MDI with VHC spacer has been shown to result in 10 times less medication deposited in the oropharynx (Dolovitch, Ruffin, Corr, & Newhouse, 1983).

MDI With Spacer

Spacer is a generic term referring to any extension device attached to an MDI. Since the vast majority of research to determine medication efficacy with MDIs utilize spacers that are VHCs, the terms have become synonymous. These spacers use a one-way inhalation valve that can significantly improve the timing and coordination issue that is so prevalent with the MDI alone. The EPR-3 has synthesized a wealth of evidence-based research that clearly supports the use of a spacer with an MDI, especially for children and anyone having difficulty coordinating an MDI (NHLBI, 2007). The spacer captures large particles of propellant that would otherwise be deposited in the mouth or throat, while significantly improving the intended small-particle deposition in the lung. The most logical case for anyone of any age or developmental level using a spacer with an MDI is that it provides a means to deliver a consistent dose of a given medication to the lungs, where it needs to reach in order to have an effect. It can be a life-saving and vital tool to achieving asthma control. School nurses consistently witness students puffing medication into their mouths that seldom reaches the lung. Using an MDI with spacer, however, still requires detailed instruction and ongoing reinforcement to optimize technique. Table 4 demonstrates the use of an MDI with spacer.

"The most logical case for anyone of any age or developmental level using a spacer with an MDI is that it provides a means to deliver a consistent dose of a given medication to the lungs, where it needs to reach in order to have an effect."

One of the most common mistakes made with using an MDI with spacer is the timing of actuating the puff (Ozkaya et al., 2010). The longer it takes to actuate the puff after the inhalation has begun, the less air is available to carry the particles into the lung. Other common mistakes are not exhaling properly before actuation, inhaling too quickly, placing multiple puffs in the spacer at one time, not fully sealing the lips around the mouthpiece or mask on the face, and breathing through the nose. These are all potential details that the school nurse can help address with any student. Once the technique appears to be mastered, it is important to reassess on a regular basis to ensure ongoing competency.

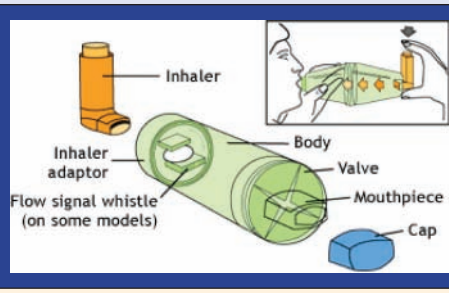
Another option that can help with young children is converting from the use of a spacer with mask to a mouthpiece. Most children by age 5 years can seal their lips around the mouthpiece and learn to take slow deep breaths, allowing for easier assessment of their technique and improved lung deposition of medication. The school nurse can collaborate with the family and provider to discuss this option.

Barriers to Spacer Use

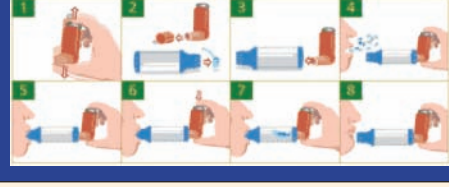
The two most common barriers to spacer use are appreciating the rationale and the cost. Before promoting this rationale to others, the school nurse needs to appreciate the impact that optimal inhalation technique can have on asthma control and how well-controlled asthma equates to fewer missed school days, fewer visits to the nurse's office, and greater academic achievement. Ideally, the student's health care provider should also encourage use of a spacer. Subsequently, through a tailored approach, with consideration of individual traits and developmentally appropriate strategies, achieving student acceptance of spacer use is often attainable. The most basic approach is a demonstration showing how an MDI sprays a puff of medication into the air in a fraction of a second, followed by a discussion of the difficulty of breathing that spray directly into the mouth at just the right fraction of a second and the right angle to get it into the lungs. The vast majority of people who have used inhalers will confirm that medication is, at least occasionally, sprayed on the tongue or the back of the throat. The school nurse is able to help the student (and parent) understand that medication not reaching the lungs is medication going to waste and not helping the student's asthma. An analogy to consider is that it is like having a headache and tossing your two pills up in the air and trying to catch them in your mouth—if you catch them both, you're in luck; if you miss one or both, they are not going to help your headache.

The out-of-pocket expense for spacers varies by state and health insurance plan. School nurses can work on an individual basis with the health provider to help families appreciate the value of investing in a spacer. School nurses can also get

Table 4. Using a Metered-Dose Inhaler (MDI) With Spacer



To use a MDI with spacer:
1. Shake the inhaler well before every use (3-4 shakes).
2. Remove the cap from your inhaler and from your spacer, if it has one.
3. Prime as indicated.
4. Put the inhaler into the spacer.
5. Breathe out all the way.
6. Bring the spacer to your mouth and close your lips around it.
7. Press the top of your inhaler once.
8. Breathe in very slowly until you have taken a full breath. If you hear a whistle sound, you are breathing in too fast—the breath in should take at least 3-5 seconds.
9. Hold your breath for about 10 seconds, then breathe out.
10. Repeat for additional puffs as indicated, waiting at least 30 seconds between puffs.



To use a spacer with mask:
1. Follow Steps 1-3 above.
2. Hold the spacer with mask to the face so that both the nose and mouth are covered. It is important to make a good seal between the face and mask so that all the medicine gets breathed in through the spacer.
3. Press the top of your inhaler once.
4. Hold the mask firmly in place while the child takes 4-6 breaths, the slower and deeper, the better.

involved with local or state asthma advocacy coalitions or groups that can work with legislators to eliminate the out-of-pocket expense for a medication delivery device that, in terms of health care dollars saved, easily pays for itself.

Additional Considerations

For school nurses who are able to provide an additional resource for student asthma education, the In-Check DIAL is a device that measures both the time and the inspiratory flow rate, simulating the use of an MDI with spacer. This unique device can be a very useful tool in helping to achieve optimal inhalation technique and determining if children and adolescents are capable of properly using specific inhalation devices (Bossard, 2010).

Spacers do require storage space, which for some school nurses is a significant concern. An average elementary school with 500 students may have 50 students with asthma who should have treatment available in school. Stackable storage bins are one approach to making good use of limited cabinet space.

There is an advantage to MDIs that have built-in counters. They can be used to ensure that medication remains in the canister, as well as for monitoring how much is used. Using a permanent ink marker to write the date the MDI was opened helps with establishing the time frame of its use. If the counter indicates that a significant amount of medication is being used over a relatively short period of time (e.g., 90 puffs in 30 days), a differentiation should be made in terms of the student's asthma control or the possibility that the medication is being shared. Excessive MDI use is often associated with inadequate inhalation technique since less medicine reaches the lung, resulting in a cycle of unresolved symptoms and excessive SABA use.

The medication administration record can be a valuable record of SABA use to determine the remaining doses for each MDI. This record is also a valuable source of frequency of use data that the school nurse can share with the provider who orders the medication. This is a good example of how the school nurse can be an effective partner with the health care provider to assist with assessing the student's asthma control. For example, providers who write school medication authorizations for albuterol every 4 hours prn have no way of knowing if the medication is given twice in a school year or 200 times.

Conclusion

The significance of optimal inhalation technique is gaining overdue appreciation

in achieving and maintaining asthma control. The school nurse is in a position to contribute to this aspect of asthma management in school and use this relationship with students to help them learn sustainable self-management principles. Additional school-based asthma priority areas should focus on assessing asthma control, obtaining and using an asthma action plan and medication self-administration plan, and working with school administration to maintain an indoor air quality program to reduce the incidence of asthma episodes in school. ■

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