

# Nebulizers versus pressurized metered-dose inhalers in preschool children with wheezing

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### Abstract

**Question** In my office, I frequently encounter children with wheezing. When I prescribe inhaled bronchodilators for preschool children, what is the recommended method of delivery—a nebulizer or a spacer?

**Answer** The pressurized metered-dose inhaler with a spacer is an effective method of delivering inhaled drugs to young children. Children younger than 5 years of age will require the additional use of a face mask. It is best to give aerosolized medications when a child is awake. Efforts to optimize the child's cooperation with medication administration by using a spacer with an appropriate mouthpiece or face mask will also improve drug delivery.

### Nébuliseurs ou aérosols doseurs chez les enfants d'âge préscolaire qui râlent

#### Résumé

**Question** Je vois fréquemment à mon cabinet des enfants qui ont une respiration sifflante. Quand je prescris un bronchodilatateur par voie inhalée à des enfants d'âge préscolaire, quel est le mode d'administration recommandé, un nébuliseur ou un spacer?

**Réponse** L'aérosol doseur pressurisé avec un spacer est une méthode efficace pour administrer des médicaments par voie inhalée à de jeunes enfants. Les enfants de moins de 5 ans ont besoin d'utiliser en plus un masque facial. Il vaut mieux donner les médicaments en aérosol lorsque l'enfant est éveillé. Des efforts pour optimiser la coopération de l'enfant lors de l'administration d'un médicament en utilisant un spacer comportant un embout buccal approprié ou un masque facial amélioreront aussi l'administration du médicament.

Wheezing is common in children and predominates in the early years of life. By 3 years of age, 33% of children—and by 6 years of age, 49% of children—will have had an illness with wheezing.<sup>1</sup> In a large survey of more than 7000 households (9490 children) across Europe and the United States,<sup>2</sup> parents reported that one-third of children had experienced recurrent days with coughing, wheezing, and shortness of breath in the previous 6 winter months. Eighty-five percent of these children visited family physicians and 35% visited physicians more than 3 times.<sup>2</sup>

Wheezing and shortness of breath in children younger than 5 years of age has a heterogenic origin, and some of these children might benefit from treatment with bronchodilators. Inhaled drug delivery in young children is limited by narrow airways, inability to generate high inspiratory flow rates, and increased airway turbulence.<sup>3</sup>

Furthermore, research assessing the effect of bronchodilators has been limited owing to the difficulties in measuring drug delivery. As measuring drug deposition in lung tissue is challenging, proxy markers such as drug excretion or filtered doses are used. The filtered dose is a method of measuring emitted dose from an inhaler that takes into account the medication

lost within the apparatus. The emitted dose provides a more accurate estimate of the drug available from a specific inhaler.

### Drug delivery

Commonly used delivery systems are nebulizers, pressurized metered-dose inhalers (pMDIs) with or without spacers, and dry-powder inhalers. Children younger than 5 years of age often cannot generate adequate inspiratory flow to effectively use dry-powder inhaler devices.<sup>4</sup>

The advantage of a nebulizer is that it can deliver drugs without the child's cooperation. When using a nebulizer, less than 10% of the aerosolized drug reaches the lungs, with large deposits remaining in the apparatus or on the face, and the remainder lost to the surroundings.<sup>5,6</sup> In comparison, pMDIs have a drug pulmonary deposition of 10% to 40%.<sup>4,7,8</sup> This large range reflects the inconsistencies in findings across studies owing to the difficulty of measuring drug deposition in lung tissue and the use of different spacer devices.<sup>4</sup>

Infants and young children lack the coordination required to trigger and simultaneously inhale a drug when using pMDIs. The use of adjuncts such as spacers with mouthpieces or face masks overcomes this difficulty. Spacers can eliminate the need for coordinated

activation of the pMDI and inhalation of the aerosol. The valved holding spacer has a one-way valve with the particular advantage of allowing aerosol to move out of the chamber at inhalation but holding particles in the chamber during exhalation. Valved spacers should not be used for neonates or infants who are unable to generate the inhalational flow to open the one-way valve. In general, children younger than 5 years of age will require face masks to assist with aerosol delivery through the spacer.<sup>5</sup> One of the limitations of the face mask is that nose breathing might considerably reduce inhaled drug delivery to the lower airways. As soon as a child can reliably breathe through a mouthpiece, he or she should transition to using it to optimize drug delivery.

### **Nebulizer versus pMDI with a spacer**

The use of a pMDI with a spacer (pMDI+S) is more effective than use of a nebulizer in young children in the emergency department setting.<sup>6,9,10</sup> A meta-analysis reported that children younger than 5 years of age with moderate to severe exacerbation of wheezing experienced reduced hospital admission rates (odds ratio 0.42, 95% CI 0.24 to 0.72) and reduction in validated clinical severity score (-0.44, 95% CI -0.68 to -0.20) with the use of pMDI+S compared with a nebulizer.<sup>9</sup> A randomized

study of children younger than 24 months of age (N=123) who presented to an emergency department with mild to moderate wheezing assessed participants for clinical improvement. The Modified Tal's Clinical Score,<sup>11</sup> a validated clinical score without pulse oximetry, was used as the outcome measure. While both groups in this study had equivalent recovery after 2 hours, the use of a pMDI+S resulted in faster symptom resolution with statistically significant improvement at 1 hour (odds ratio 3.9, 95% CI 1.5 to 10.4).<sup>6</sup>

### **Uncooperative children**

Optimizing a child's cooperation is important, as compliance with treatment affects medication delivery.<sup>8</sup> In a randomized study, 94% of parents with children 12 to 60 months old reported that spacers were easier to use than nebulizers, and 62% believed that the pMDI+S was better accepted by their children.<sup>10</sup> A study of breathing patterns in children 2 to 7 years old demonstrated no difference in drug delivery with 3 to 9 tidal breaths<sup>12</sup>; therefore, it is recommended that a child breathes at least 3 tidal breaths through an appropriate spacer. Many younger children find receiving aerosolized medication distressing and as a result are not breathing at tidal volumes at the time of delivery; only one-quarter of

the aerosolized drug is deposited in distressed children compared with the amount deposited in calm infants.<sup>8</sup>

Some experts have advocated administration of aerosols during sleep to enhance drug delivery in uncooperative children.<sup>13</sup> However, drug doses delivered during sleep via a pMDI+S are unpredictable, as parents are often reluctant to firmly and correctly place the face mask on a sleeping child. Breathing patterns during normal sleep cycles also vary, as can be seen during rapid eye movement sleep cycles. Furthermore, a feasibility study demonstrated that children were unlikely to remain asleep during aerosol administration. Sixty-nine percent of children woke up during medication delivery with most (70%) expressing distress, which compromised drug delivery.<sup>13</sup> Only a small subset of children who are particularly uncooperative with treatment might demonstrate improvement with pMDI+S administration during sleep, as long as they stay asleep during treatment.<sup>13</sup> Drug delivery in these circumstances remains variable.<sup>8</sup>


### Conclusion

Inhaled therapies are effectively administered by pMDI+S to children younger than 5 years of age. Pressurized metered-dose inhalers with spacers are portable and better tolerated when compared with nebulizers. To optimize the child's compliance with treatment and to achieve effective medication delivery, a mouthpiece or well-fitted face mask (Box 1<sup>14</sup>) should

#### Box 1. Face mask fit

The selection of a face mask contributes to effective drug administration. Good fit, flexibility, and dead space in the mask are important considerations in selecting a face mask. The mask should fit in such a way as to minimize leaks, and the dead space in the mask should be eliminated to maximize drug delivery to the lungs. In infants and neonates, dead space in a mask or a spacer might contribute to a considerable proportion of their tidal volumes. The flexibility of the face mask also improves the fit and reduces dead space by allowing gentle compression of the mask to the child's face.

Data from Amirav and Newhouse.<sup>14</sup>

be an adjunct to the pMDI+S. Children should graduate to a mouthpiece by about 5 years of age. The effect of administering aerosolized medications to a sleeping child is unpredictable. 

#### Competing interests

None declared

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