

Automatic replacement of albuterol nebulizer therapy by metered-dose inhaler and valved holding chamber

LESLIE HENDELES, RANDY C. HATTON, TIMOTHY J. COONS, AND LEAH CARLSON

Many studies over the past 18 years have shown that a β_2 -agonist inhalation suspension delivered by a metered-dose inhaler through a valved holding chamber (MDI+VHC) is as effective in relieving acute bronchospasm as delivery through a small-volume nebulizer (SVN).¹⁻¹⁵ MDI+VHC is more efficient,¹⁶ faster,¹⁷⁻¹⁹ and more convenient than SVN. In several studies in children, this method of delivery was associated with fewer adverse effects than SVN,^{1,5,10,13,15,20} and a recent meta-analysis suggested that it was more effective in children younger than five years.²¹ Because less time is needed to administer a dose, switching from SVN to MDI+VHC may save time for respiratory therapists¹⁷⁻¹⁹ and may save hospital costs.^{13,17-19,22} In addition, this mode of therapy is less expensive for ambulatory care patients with asthma. Nevertheless, physicians have been slow to adopt MDI+VHC. This has been true at our own institution, even though one of the first double-blind, randomized studies demonstrating equivalent efficacy of the two meth-

Purpose. Evidence supporting the delivery of bronchodilators with a metered-dose inhaler and a valved holding chamber (MDI+VHC) in place of a small-volume nebulizer (SVN) is discussed, and the steps taken to accomplish such a conversion program at one institution are described.

Summary. Double-blind, randomized studies in patients with acute exacerbations of asthma have demonstrated that higher doses of albuterol delivered by MDI+VHC (4–10 puffs per dose) are as effective as 2.5 mg of albuterol sulfate delivered by SVN. Three double-blind studies support the conclusion that the two methods are equivalent with respect to both efficacy and adverse effects in patients with chronic obstructive pulmonary disease. MDI+VHC offers practical advantages over SVN, including the capacity for home use by the patient, portability, less setup time, and no need for daily disinfection. Pharmacists and respiratory therapists obtained approval through the pharmacy and thera-

peutics committee for respiratory therapists to convert orders for bronchodilators delivered by SVN to administration by MDI+VHC. The conversion policy allows physicians to override it, but none have exercised this option. On intensive care units (ICUs), the policy resulted in a 53% increase in the use of MDI+VHC during the six-month period after it went into effect. Respiratory therapists have been less thorough in implementing the policy for non-ICU patients.

Conclusion. Delivery of bronchodilators by MDI+VHC is as effective as delivery by SVN but offers several advantages. A policy to switch patients from SVN to MDI+VHC for bronchodilator administration met with limited success.

Index terms: Administration; Albuterol sulfate; Asthma; Devices; Dosage; Hospitals; Inhalers; Lung diseases; Sympathomimetic agents; Toxicity

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ods of albuterol delivery was conducted in our own emergency department (ED) over 10 years ago.⁶

We were convinced that MDI+VHC offers important advantages, but our attempts to change

prescribing behavior in our institution through education had failed. We therefore obtained approval from the pharmacy and therapeutics (P&T) committee for respiratory therapists to automatically use

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MDI+VHC when a physician orders bronchodilator therapy by SVN.

The purpose of this report is to discuss the scientific evidence supporting the use of MDI+VHC in place of SVN to deliver bronchodilators and the steps we took to accomplish such a conversion program at our institution.

Rationale for MDI+VHC

Efficacy of albuterol delivered by MDI+VHC versus nebulizer in patients with asthma. Double-blind, randomized, parallel-group studies in patients with acute exacerbations of asthma have demonstrated that higher doses of albuterol sulfate delivered by MDI+VHC (e.g., 4–10 puffs per dose) are as effective as 2.5 mg of albuterol delivered by SVN (Table 1). These studies have been conducted in adults (persons older than 18 years),^{2,6,8,9,14} adolescents and children (5–18 years),^{3,5,6,10} and young children (2 months to 4 years).^{11–13,15} In young children, the VHC must be attached to a mask that forms a tight seal around the nose and mouth (Figure 1). A similar device with a larger mask can be used in elderly patients. Also, a VHC with an adapter has been used to administer medication by MDI into a ventilator circuit in patients receiving mechanical ventilation.^{17,23}

Only one study found that albuterol delivered by SVN was marginally more effective than MDI+VHC.²⁰ In that study, three puffs were delivered at once rather than sequentially, as in most other studies. In all other studies, delivery of albuterol by MDI+VHC was at least equivalent to SVN with respect to all outcome measures, including pulmonary function, arterial oxygen saturation, and rate of hospitalization after treatment in the ED (Table 1). For example, in a double-blind, double-dummy, randomized study in adults with acute asthma treated in an ED, pulmonary function improved to the same extent after deliv-

ery of albuterol by MDI+VHC as after delivery by SVN (Figure 2).⁶

However, while patients in the ED studies had acute asthma, MDI+VHC has not been studied in the most severely ill group of patients, that is, those requiring albuterol by continuous nebulization. In many of the double-blind studies in children, systemic adverse effects, such as a heart-rate increase, were less pronounced in those receiving medication by MDI+VHC than by SVN,^{5,10,13,15,20} probably as a consequence of swallowing and absorbing into the bloodstream a larger amount of drug during nebulization. In contrast, most studies in adults have found no significant difference in adverse effects between the two methods of delivery (Table 1).

A meta-analysis of double-blind, randomized, controlled trials in the ED confirmed that there is no loss of efficacy when β_2 -agonists are delivered by MDI+VHC.²⁴ A meta-analysis is particularly important when individual studies are insufficiently powered to detect differences in less frequent outcomes, such as hospitalization rate. A large range of doses were used in these studies. In the only study comparing two levels of doses delivered by MDI, there was a trend toward lower efficacy with 2 puffs than with 6–10 puffs.¹⁰ Moreover, in children younger than 5 years, a recent meta-analysis indicated that delivery by MDI+VHC was associated with a significantly lower hospital admission rate and greater improvement in clinical scores than with nebulizer therapy.²¹

Efficacy for chronic obstructive pulmonary disease (COPD). Only three double-blind, randomized studies have compared MDI+VHC with SVN delivery of β_2 -agonists in patients with acute exacerbations of COPD, and all found equivalent efficacy (Table 2).^{2,8,25} Several additional unblinded or nonrandomized studies support the conclusion that the two methods are equivalent with re-

spect to both efficacy and adverse effects in patients with COPD.^{18,22,26–30} No studies looked at the delivery of ipratropium alone or in combination with albuterol in acutely ill patients with COPD. However, two studies in patients with stable COPD suggested that four puffs of the combination of albuterol and ipratropium delivered by MDI+VHC produced bronchodilation similar to that achieved by 2.5 mg of albuterol and 0.5 mg of ipratropium delivered by SVN.^{31,32}

Practical advantages of MDI+VHC. Heidarian-Raissy and Kelly³³ recently claimed that the clinical trials comparing MDI+VHC with SVN are biased to show no difference in responses and that no data support one method over the other in patients with mild to moderate asthma “either clinically or economically.” They concluded that “equality to a standard that has not been shown to produce an improvement in outcomes for the last 20 years is hardly a finding worth changing the standard of care” for. However, they did not consider the decrease in tachycardia in children,^{5,10,13,15,20} the greater efficacy in young children (less than five years),²¹ and some of the practical advantages of MDI+VHC. For example, children treated in the ED or hospital usually require continued therapy with a bronchodilator after discharge. If albuterol is delivered by MDI+VHC in the hospital, parents can learn to use this method correctly and can take home the VHC without having to search for (and pay) a respiratory therapy company to come to the home and set up a compressor and nebulizer. Similarly, ambulatory care patients attending clinics who do not have a nebulizer can be given a prescription for MDI+VHC at a considerable cost saving. For patients at our institution, a compressor must either be rented for \$50 per month or purchased for \$150, whereas a VHC costs only \$20 through a supplier of durable medical equipment (about

Table 1. Randomized, Double-Blind Trials of Albuterol Delivered by Metered-Dose Inhaler through Valved Holding Chamber or Nebulizer for Acute Asthma^a

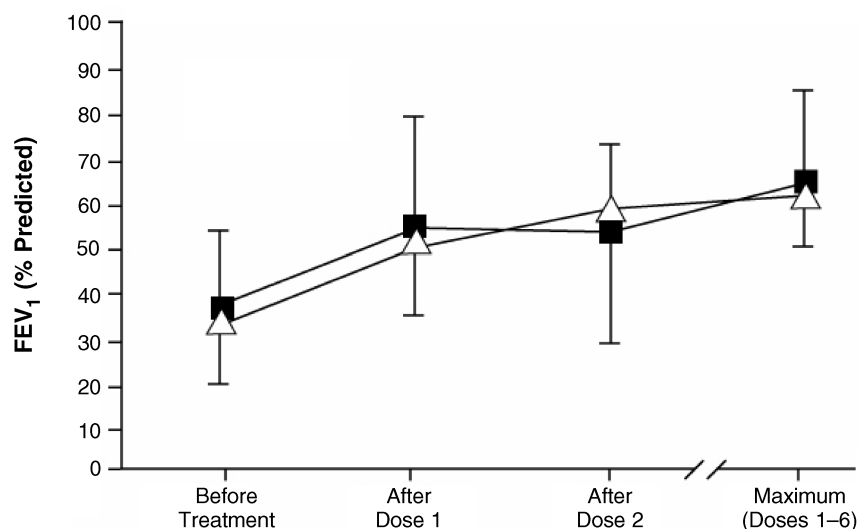
Reference	Study Group	Dosage	n	Measurements	Efficacy Results	Adverse Reactions
5	MDI (mean age, 10 yr)	1 dose: <25 kg, 600 µg; 25–35 kg, 800 µg; ≥35 kg, 1 mg	17	Clinical score, respiratory rate, O ₂ saturation, FEV ₁	MDI = SVN for all variables	MDI < SVN for HR
	SVN (mean age, 11 yr)	0.15 mg/kg to maximum of 5 mg × 1 dose	16			
6	MDI (median age, 23 yr)	360 µg every 30 min for maximum of 6 doses	15	% predicted FEV ₁ , LOS	MDI = SVN for all variables	MDI = SVN for HR and BP
	SVN (median age, 25 yr)	2.5 mg every 30 min for maximum of 6 doses	20			
47	MDI (mean age, 41 yr)	400 µg every 30 min	40	Symptom score, FEV ₁ , respiratory rate	MDI = SVN for all variables	MDI = SVN for HR and tremor
	SVN (mean age, 43 yr)	2.5 mg every 30 min	40			MDI = SVN
9	MDI (mean age, 33.1 yr)	400 µg every 10 min	11	FEV ₁ , PEF, O ₂ saturation	MDI = SVN for all variables	
	SVN (mean age, 31.7 yr)	1.5 mg every 15 min	11			
20	MDI (mean age, 6.9 yr)	1 dose: <25 kg, 600 µg; >25 kg, 1200 µg	77	Clinical score, % predicted PEF, O ₂ saturation	SVN > MDI for clinical score and PEF	MDI < SVN for HR
	SVN (mean age, 7 yr)	1 dose: <25 kg, 2.5 mg; >25 kg, 5 mg	78			
10	MDI, high dose (mean age, 9.1 yr)	1 dose: <25 kg, 600 µg; 25–35 kg, 800 µg; ≥35 kg, 1 mg	30	% predicted FEV ₁ , respiratory rate, O ₂ saturation, accessory muscle score, wheezing score, dyspnea score	MDI = SVN for all variables Trend toward higher MDI dose > lower MDI dose	MDI < SVN for HR
	MDI, low dose (mean age, 8.9 yr)	200 µg × 1 dose	30			
11	SVN (mean age, 9.6 yr)	0.15 mg/kg to maximum of 5 mg × 1 dose	30			
	MDI (mean age, 24.8 mo)	50 mg/kg every 20 min × 3 doses	32	Pulmonary index, hospitalization, ease of use, acceptability, O ₂ saturation	MDI = SVN for all variables, except MDI > SVN for ease of use and acceptability	MDI = SVN
12	SVN (mean age, 25.5 mo)	0.15 mg/kg every 20 min × 3 doses	32			
	MDI (mean age, 24.1 mo)	400 µg every 20 min × 3 doses	23	Clinical score, respiratory rate, O ₂ saturation, hospital admission	MDI = SVN for all variables	MDI = SVN for HR
13	SVN (mean age, 23.5 mo)	2.5 mg every 20 min × 3 doses	19			
	MDI (mean age, 36 mo)	500 µg every 20 min for maximum of 6 doses	30	Clinical score, respiratory rate, O ₂ saturation, wheezing, hospital admission, and cost	MDI > SVN for wheezing, hospital admission, and cost	MDI < SVN for HR
15	SVN (mean age, 32.3 mo)	2.5 mg every 20 min for maximum of 6 doses	30			
	MDI (mean age, 11.7 mo)	270 µg every 20 min	83	Hospital admission rate, O ₂ saturation, pulmonary index score, no. treatments, corticosteroid use	MDI > SVN for hospital admission rate, no. doses needed, and corticosteroid use; MDI = SVN for other variables	MDI < SVN for HR, MDI = SVN for vomiting
	SVN (mean age, 11.7 mo)	0.15 mg/kg every 20 min	85			

^aMDI = metered-dose inhaler with valved holding chamber, SVN = small-volume nebulizer, O₂ = oxyhemoglobin, FEV₁ = forced expiratory volume in one second, HR = heart rate, LOS = length of stay in emergency department, BP = blood pressure, PEF = peak expiratory flow.

Figure 1. A two-year-old child with asthma receiving treatment with a metered-dose inhaler (MDI) and a valved holding chamber (VHC). The VHC is an AeroChamber Plus (Forest Pharmaceuticals, Inc., St. Louis, MO) with a medium mask attached. The mask must form a tight seal around the nose and mouth. An exhalation valve (in front of the child's nose) moves with each exhalation and gives visual confirmation that the child is inhaling medication. This device requires six inhalations for each MDI puff.



Figure 2. Mean \pm S.D. forced expiratory volume in 1 second (FEV_1) in 35 patients 10–45 years of age treated for acute asthma with albuterol four puffs (one puff every 60 seconds) delivered by metered-dose inhaler (Δ) or with albuterol sulfate 2.5 mg every 30 minutes delivered by small-volume nebulizer (\blacksquare) until they became symptom free or six doses had been administered. Data from reference 6.



\$60 if purchased from a pharmacy). In addition, an MDI+VHC is portable, does not require a source of electricity, requires less time than a compressor and nebulizer for setup and disassembly, and does not require daily disinfection. Portability is a particular advantage during travel and for children in daycare or in those who spend time in different homes because of family circumstances.

Other considerations. In a number of countries, such as Canada, Denmark, and Australia, SVN is no longer used for treating asthma. In fact, it has been suggested that nebulizers are obsolete.³⁴ Since about a third of young children have difficulty using a VHC with a mask,¹¹ and since there are no data demonstrating that MDI+VHC is effective in patients with severe exacerbations requiring continuous nebulization of albuterol, we believe that nebulizer therapy is not obsolete, just unnecessary for most patients. Other disadvantages of MDI+VHC include the need to train staff, patients, and parents on how to use it and the time involved in setting up a new system in an institution to make the devices readily available and to charge the patient appropriately. For financial reasons, elderly patients may resist the conversion to MDI+VHC after discharge. Medicare Part B currently covers 80% of the cost of a compressor, nebulizer, and drug. In some instances, the provider may waive the 20% copayment, and patients receive their device and drug at no cost. Thus, a switch to MDI+VHC could increase their out-of-pocket expenses. However, Medicare has proposed to dramatically reduce reimbursement for respiratory therapy drugs in 2005 and to cover MDIs with the implementation of the Part D Drug Benefit in 2006 (CMS-1429-P). If this rule is enacted, the financial advantage of nebulizer therapy for the elderly will vanish.

Nebulizer solutions packaged in low-density polyethylene vials may

Table 2. Randomized, Double-Blind Trials of β_2 -Agonists Delivered by Metered-Dose Inhaler through Valved Holding Chamber for Acute Exacerbations of Chronic Obstructive Pulmonary Disease^a

Reference	Study Group	Drug and Dosage	n	Measurements	Efficacy Results	Adverse Reactions
2	MDI (mean age, 44 yr)	Metaproterenol 1.95 mg at 30-min intervals \times 3 doses	37	FEV ₁ , dyspnea score, need for corticosteroids, additional ED treatment, hospitalization	MDI = SVN for all variables	MDI < SVN for HR
	SVN (mean age, 44 yr)	Metaproterenol 15 mg at 30-min intervals \times 3	38			
25	MDI (mean age, 68 yr)	Albuterol 360 μ g \times 1 dose crossed over to SVN after 4 hr for 1 dose	20	FEV ₁ , FVC, Borg score	MDI = SVN for all variables	MDI = SVN for BP and HR
	SVN (mean age, 68 yr)	Albuterol 2.5 mg \times 1 dose crossed over to MDI after 4 hr for 1 dose	20			
8	MDI (mean age, 65.8 yr)	Albuterol 200 μ g every 15 min \times 3 doses	25	FVC, FEV ₁ , FEF ₂₅₋₇₅ /response score	MDI = SVN for all variables	MDI = SVN
	SVN (mean age, 63.3 yr)	Albuterol 1.5 mg every 15 min \times 3	25			

^aMDI = metered-dose inhaler with valved holding chamber, SVN = small-volume nebulizer, FEV₁ = forced expiratory volume in one second, ED = emergency department, HR = heart rate, FVC = forced vital capacity, BP = blood pressure, FEF₂₅₋₇₅ = forced midexpiratory flow.

contain contaminants from their labels and packaging.³⁵ Apparently, the plastic vials are permeable, allowing ingress of volatile chemicals that may be sensitizing, irritating, or even toxic to the respiratory tract. In an attempt to reduce contamination, some manufacturers have replaced ink labels with embossing and debossing of the vial. However, USP and FDA report medication errors resulting from the difficulty in reading the embossed or debossed labeling on the vials.^{36,37} Also, look-alike packaging has caused medication errors, especially in elderly patients. Delivery of bronchodilators by MDI+VHC should eliminate these problems.

Efficacy of levalbuterol

Currently, levalbuterol is available only in a nebulized dosage form, but the manufacturer has received FDA approval for a hydrofluoroalkane-propelled MDI that will be available in the near future.

The manufacturer of levalbuterol believes that its drug is more effective than racemic albuterol and therefore can be used at lower dosages, resulting in fewer adverse effects. While there are no studies comparing levalbuterol delivery by SVN versus MDI+VHC, most of the available evidence indicates that levalbuterol is neither more effective nor safer than racemic albuterol delivered by SVN,³⁸⁻⁴¹ just more expensive.³⁸ All the therapeutic and systemic effects of racemic albuterol are a result of the R-isomer.⁴⁰ When therapy consists of equimolar doses of (R)-albuterol (i.e., a 1:2 ratio of levalbuterol to racemic albuterol), improvement in lung function and systemic effects are equivalent. There are claims that the (S)-albuterol component of the racemic formulation is deleterious. While this is true in guinea pig studies and some in vitro studies, controlled studies in humans with asthma indicate that multiple doses of (S)-albuterol neither increase airway responsiveness nor

antagonize the therapeutic effects of (R)-albuterol.^{39,41}

In a single-center, double-blind, randomized study in 482 children with acute asthma being treated in an ED, 36% of those treated with repeated doses of levalbuterol required hospitalization, compared with 45% of those treated with racemic albuterol ($p = 0.02$); both drugs were delivered by SVN.⁴² There were no significant differences in secondary endpoints or adverse effects between the two treatments, and pulmonary function was not measured. In a similar double-blind study in children coming to an ED with acute exacerbations of asthma, levalbuterol was not significantly different from equimolar doses of racemic albuterol with respect to change in clinical scores, hospital admission rate, or forced expiratory volume in one second in the one third of patients able to submit to spirometry.⁴³ Fewer patients in the levalbuterol-treated group reported nausea, but the statistical test used for this determination was repeated for each adverse effect without correction for multiple comparisons (i.e., there was a possible type I error). In a subsequent double-blind, randomized, multi-center study in adults treated for acute asthma in the ED, there was no significant difference in hospital admission rates between recipients of levalbuterol and recipients of racemic albuterol.⁴⁴ Thus, the findings of the single-center study⁴² have not been confirmed. One possible explanation is that that study had a type I error. A less likely reason for the difference might be that patients in that study had more severe exacerbations than those in the other two ED studies cited above.

FDA does not allow the manufacturer, Sepracor, to claim that levalbuterol is more effective or safe than racemic albuterol. In advertisements, the company is allowed only to make the statement “devoid of the unnecessary left isomer, (S)-albuterol.”

Also, FDA denied approval of levalbuterol for children two to five years of age because of concerns about greater adverse outcomes when it is given three times daily for three weeks.⁴⁵ In a randomized, double-blind, parallel-group study, asthma exacerbations (resulting in the need for a short course of oral corticosteroids, an unscheduled visit to a physician, an ED visit, or hospitalization) and adverse effects were more frequent in children treated with levalbuterol than in those treated with either racemic albuterol or placebo (Figure 3). However, the significance of these differences was not reported. Moreover, nebulized levalbuterol is an as-needed therapy and is not recommended for maintenance therapy (as it was used in this study) in the National Institutes of Health guidelines for asthma.⁴⁶

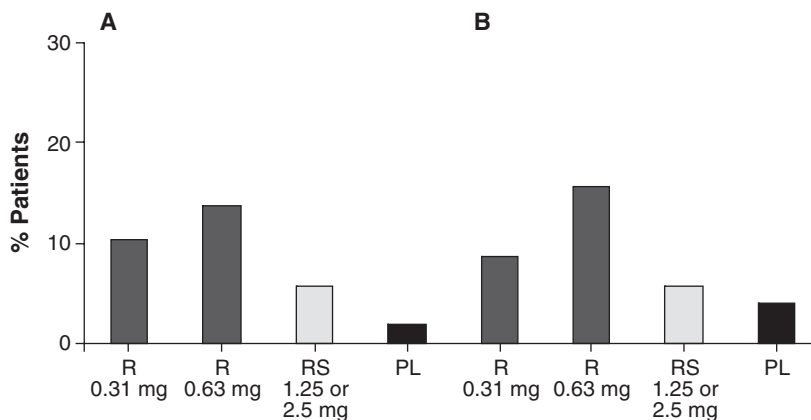
Conversion from SVN to MDI+VHC

Educational efforts. A pharmacist with expertise in asthma pharmacotherapy presented the scientific evidence supporting a change in delivery methods during pediatric grand rounds, an ED conference, and two separate pediatric house staff conferences at our hospital. Pulmonary attending physicians in both pediatrics

and medicine supported the recommended change from SVN to MDI+VHC. At these sessions, the pharmacist demonstrated administration technique and addressed concerns. Also, the satellite pharmacies were stocked with VHCs with mouthpieces and masks of different sizes and albuterol MDIs so that everything required was readily available. Despite these efforts, the house staff continued to prescribe nebulizer therapy.

Conversion policy on intensive care units (ICUs). Initial efforts to switch from SVN to MDI+VHC for albuterol, ipratropium, and the combination of the two bronchodilators were limited to patients being mechanically ventilated in the surgical ICU (SICU). An interdisciplinary committee consisting of representatives from respiratory care, pharmacy, nursing, and hospital administration and SICU attending physicians reviewed the literature and recommended implementing the conversion policy in two stages. During the first stage, the respiratory therapist asked the prescribing physician to change the order to MDI+VHC for each patient (i.e., the conversion was not automatic and required a written physician order). After widespread acceptance of this policy, the P&T

Figure 3. Frequency of asthma exacerbations (A) and adverse events requiring patient withdrawal from the study (B) in 211 children two to four years of age treated with placebo (PL), 0.31 or 0.63 mg of levalbuterol (R), or 1.25 or 2.5 mg of racemic albuterol (RS) three times a day for three weeks. Adapted from reference 45.



committee approved a pilot program allowing automatic conversion by respiratory therapists in all ICUs, including the medical ICU, for all adult patients receiving SVN, not just those on ventilators. Patients were excluded if they required continuous nebulization or more than four doses per hour, if the bronchodilators were mixed with other drugs (e.g., *N*-acetylcysteine), or if the physician specified that MDI+VHC should not be used. The respiratory therapist recorded the change on the physician order sheet and administered all treatments.

Hospitalwide conversion policy. After several months of success with the pilot program, a pharmacist urged respiratory care services, in consultation with the interdisciplinary committee and pulmonologists, to expand the conversion policy to cover all patients receiving nebulized bronchodilators, including children, throughout the hospital. The policy was presented to the P&T committee, and the pharmacist and the director of respiratory care answered questions posed by committee members. The policy was approved unanimously.^a

The interdisciplinary committee believed that a change in delivery method would not increase the workload on nursing and that respiratory care should remain involved. Accordingly, the new policy requires that the respiratory therapist use MDI+VHC for the first 24 hours, followed by assessment of the patient's or caregiver's ability to use it effectively. If the patient or caregiver can do so, the patient's nurse subsequently observes the administration of each dose and records it in the medication administration record. The respiratory therapist continues to administer each dose if the patient cannot do so effectively or if the patient has a tracheostomy tube requiring a VHC with an adapter.

When a physician writes an order for SVN and there are no reasons not

to use MDI+VHC, the respiratory therapist records the switch on the physician order sheet, along with the corresponding dose for inhaler use (Table 3). Patients are excluded from the conversion if administration is more frequent than every four hours, nebulized bronchodilators are mixed with other drugs, the patient is younger than six months, or the physician's order specifies no conversion. The order is reviewed by the pharmacist, and the respiratory therapist obtains the MDI+VHC from a satellite pharmacy.

A pharmacist trained a team from respiratory care services that in turn taught all the respiratory therapists the rationale for the change, how to determine which device to use, how to use it, how to teach the patient to use it, and how to assess the patient's effectiveness. Training in the use of the VHC with mask attachment was given to nurses caring for pediatric patients on all shifts by the respiratory care services team.

A new MDI is dispensed for each patient and discarded upon discharge. The patient can take the VHC home upon discharge, but the physician must write a prescription for the MDI, since the canister used in the hospital is not labeled for outpatient use. Some institutions may choose to use a single MDI for several patients, but such a procedure

should be approved by the infection control officer.

In our ED, bronchodilators are administered by nurses and not respiratory therapists. As a consequence, the conversion policy does not apply to that setting. We have stocked the automatic dispensing cart in the ED with MDIs and VHCs with mouthpieces and masks of various sizes, including one for geriatric patients. The pharmacist met with ED physicians and nurses to review the rationale for the use of MDI+VHC and to train these nurses to administer MDI with different VHCs.

Outcomes. The conversion policy was initiated on all ICUs during November and December of 2003. In the following six-month period, the use of SVN decreased (from 27,591 to 19,159 treatments, a 30% decline), and the use of MDI increased (from 5,908 to 9,023 treatments, a 53% jump) compared with the same period a year before the policy change. Also, hospital purchases of VHCs increased 80% between 2003 and 2004.

An assessment of orders for bronchodilators on all ICUs for a single day indicated that 47% of patients met exclusion criteria and continued to use SVN. A majority of these patients were excluded because *N*-acetylcysteine was ordered to be mixed with a bronchodilator. Simi-

Table 3.
Dose Conversion from Nebulizer Therapy to MDI+VHC^{46,a}

Prescribed Nebulizer Drug and Dose ^b	Corresponding Dose for MDI+VHC with Mouthpiece ^c	Corresponding Dose for MDI+VHC with Mask ^d
Albuterol 2.5 mg	4 puffs	4 puffs
Albuterol 5 mg	8 puffs	8 puffs
Ipratropium bromide 0.5 mg	4 puffs	8 puffs ^e
Albuterol 2.5 mg + ipratropium bromide 0.5 mg	4 puffs (combined product) ^e	4 puffs (combined product) ^e

^aMDI+VHC = metered-dose inhaler with valved holding chamber.
^bRespiratory therapist contacts physician if prescribed nebulizer dose differs from those listed or if response to MDI is considered inadequate.
^cFor patients who can perform a slow, deep inhalation and hold their breath for 5–10 seconds on command.
^dFor patients younger than four years or who are unable to perform a slow, deep inhalation or hold their breath for 5–10 seconds on command.
^eNot recommended in children, for whom there are no data on the use of ipratropium delivered by MDI+VHC. The combined product (Combivent, Boehringer Ingelheim) contains albuterol 90 µg (as the sulfate salt) and ipratropium bromide 18 µg per puff.

lar data are not available for the hospital wards (non-ICU patients), but a single-day assessment indicated that none of the patients were switched from SVN to MDI+VHC, while only 9% met exclusion criteria. The lack of adherence to the policy was a result of personnel changes and failure of the respiratory therapy supervisor to train new staff. To remedy this situation, the director of respiratory care assigned a supervisor to review SVN orders daily on the hospital wards and to recommend the conversion, when appropriate, to the patient's respiratory therapist.

To our knowledge, no physician has written a "do-not-substitute" order since the policy was implemented. However, physicians continue to prescribe SVN for treatment in the ED but now discharge patients with an MDI+VHC. The only exception is when a treatment room is not available, in which case the patient is treated in the hallway, where an air source for the nebulizer is not available. Under those circumstances, ED physicians prescribe bronchodilators by MDI+VHC. Thus, the full potential of this initiative may not be achieved until at least one ED physician champions the cause.

Our efforts to widen the use of MDI+VHC have been successful on ICUs but not, so far, on non-ICU units. With additional efforts on the part of respiratory care management, we believe that the policy will be followed and will save substantial time for respiratory therapists. Patients and caregivers will have learned how to use the MDI+VHC and will be able to take the VHC home. Thus, they will have a more convenient and less expensive method of delivering inhaled medications.

Conclusion

Delivery of albuterol by MDI+VHC is at least as effective as delivery by SVN and is faster, more convenient, and less expensive. A

policy to switch patients from SVN to MDI+VHC for bronchodilator administration at one hospital met with limited success.

^aThe conversion policy is available on request from carlslm@shands.ufl.edu.

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