Breath-by-breath Delivered Dose Comparison from Three Anti-Static Valved Holding Chambers With Facemasks Under Simulated Use Conditions

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Introduction

Valved holding chambers (VHCs) are used to facilitate drug delivery to patients who lack the coordination skills to use pressurized metered dose inhalers (pMDIs) effectively. Facemasks are a patient-device interface used to facilitate the delivery of inhaled drugs in a select subgroup of patients, such as young children who are unable to use a VHC mouthpiece effectively (1). Facemasks are often overlooked as a factor which can influence inhalation drug therapy, however they are now gaining increasing attention as an important component capable of significantly affecting overall inhalation drug therapy (2-5). Despite this, the methodology surrounding the evaluation of facemask performance has remained scant and unclear. A novel in vitro facemask horizontal test rig, developed jointly with Philips Respironics, was recently introduced and validated for evaluating facemask performance (6-7). By way of an interchangeable soft model face, the facemask horizontal test rig is capable of realistically simulating clinically relevant parameters such as adjustable facemask position on faces, facemask applied force, and application angle, in addition to functionality for flow connection to a breathing simulator. The facemask test rig can be used to determine the percent facemask seal leakage and aerosol deposition including delivered dose from various brands of VHC-facemask systems.

The objective of this study was to compare the performance of several VHC-facemask systems by analyzing delivered dose via a breath-by-breath approach.

Method

Each anti-static VHC was tested with its marketed facemask of the recommended size:

- Pre-production OptiChamber Diamond VHCs with LiteTouch facemasks (Philips Respironics, Respironics New Jersey, Inc., Parsippany, NJ)
- AeroChamber® Plus Z STAT® VHCs with ComfortSeal® facemasks (Monaghan, Plattsburg, NY)
- Vortex® VHCs with Spinner® Duck facemasks (PARI, Midlothian, VA)

A previously published optimal setting determination for each VHC-facemask system was used, designated as the height of the face replica which produced the lowest percent leakage (7).

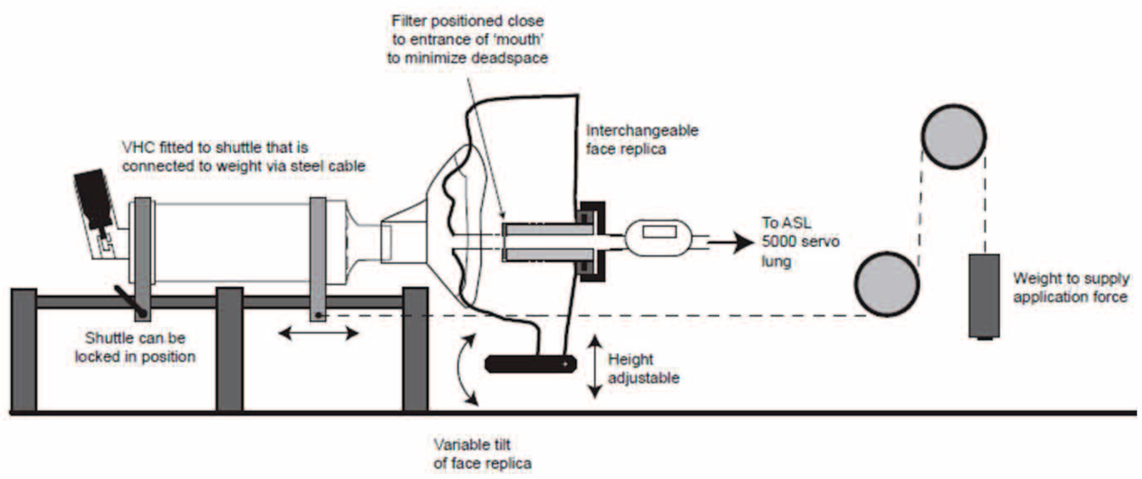

Figure 1. Setup to determine delivered dose.

Figure 2. Photos of each VHC-facemask system tested under 0° face replica tilt, 1.9 kg applied force for 1 simulated pediatric breath: (Left) OptiChamber Diamond-LiteTouch, (Middle) AeroChamber Z Stat-ComfortSeal, (Right) Vortex-Spinner Duck.

Each VHC-facemask system was attached to a face replica (Figure 2) with the downstream side of the face replica/ filter connected to a breathing simulator (ASL 5000, IngMar Medical, Pittsburgh, PA) which simulated a pediatric breathing pattern (tidal volume=155 ml, breathing rate=25 breath/min, inhalation to exhalation ratio=40:60). An applied force exerted by an attached mass of 1.9 kg was used for 4 simulated pediatric breath settings (1, 2, 4, or 8 breaths) as shown in Figure 1.

Each pMDI (ProAir HFA, 108 µg albuterol sulfate (salbutamol); Teva Specialty Pharmaceauticals LLC) was actuated 5 times into the VHC during each test to ensure a quantifiable amount of albuterol was collected on the filter. Albuterol sulfate recovered from the filter (delivered dose) and the pMDI actuator-VHC-facemask combination (residual dose) was quantified by HPLC.

Results

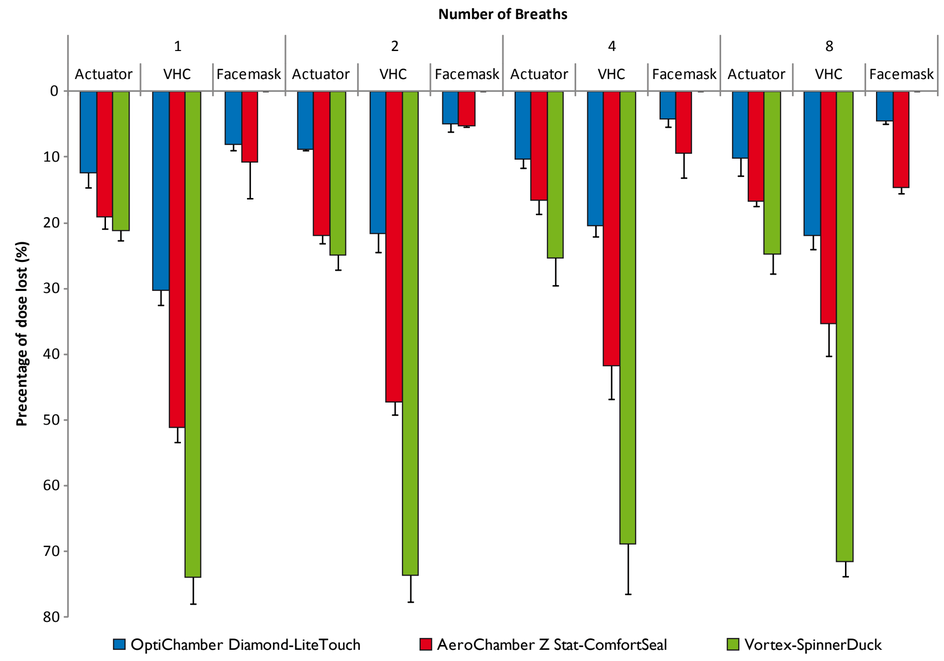

Figure 3. Percentage of nominal dose of albuterol lost to each part of the pMDI actuator-VHC-facemask combination.

Overall the lowest residual doses of albuterol deposited within the pMDI actuator-VHC-facemask combination were found using the OptiChamber Diamond-LiteTouch system. The highest residual doses of albuterol deposited within the pMDI actuator-VHC-facemask combinations were found using the Vortex-Spinner Duck system.

The delivered dose, in terms of percentage of the nominal dose recovered from the filter, was higher using the OptiChamber-LiteTouch system than both the AeroChamber Z Stat-ComfortSeal and Vortex-Spinner Duck systems across all breath settings studied.

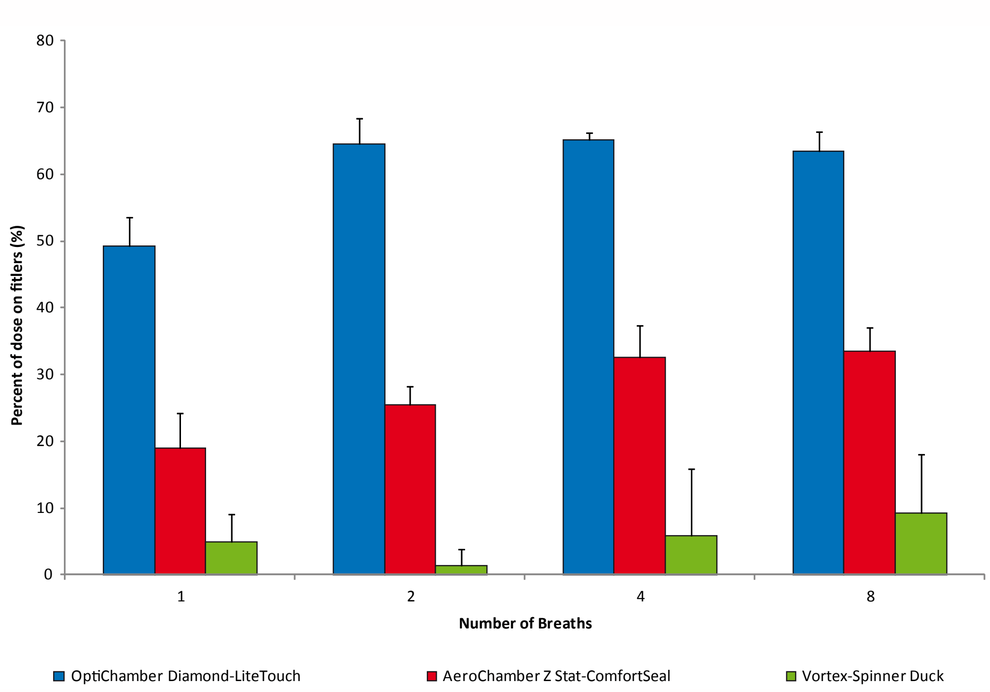

Figure 4. Percentage of drug recovered from the filters for each VHC-facemask system under 4 breath settings (bars represent mean ± SD, n=3).

The delivered dose of albuterol after 1 breath using the OptiChamber Diamond-LiteTouch system was significantly higher than the delivered dose after 8 breaths using the two other systems ($p<0.01$). A general pattern was observed regarding approximately how many breaths were necessary for each VHC-facemask system to reach a consistent delivered dose. For the OptiChamber Diamond-LiteTouch system, it took approximately two simulated pediatric breaths to achieve a consistent delivered dose, whereas it took at least four breaths for both the AeroChamber Z Stat-ComfortSeal system and the Vortex-Spinner Duck system to achieve their own, albeit lower, consistent delivered dose.

Conclusions

The results show that the delivered dose after 1 breath using the OptiChamber Diamond-LiteTouch system was significantly higher than the delivered dose after 8 breaths using the AeroChamber Z Stat-ComfortSeal system or the Vortex-Spinner Duck system. The OptiChamber Diamond-LiteTouch system achieved the highest delivered dose overall and in the least number of breaths.

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