A Performance and Cost Comparison of Four Valved Holding Chambers During Simulated Uncoordinated Breathing
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Introduction
Valved holding chambers (VHCs) are widely prescribed to patients for whom coordinated breathing is difficult. For such patients, there may be a brief time lapse between metered-dose inhaler (MDI) actuation into the VHC and inhalation, during which time drug can deposit and be lost inside the VHC chamber. To simulate such uncoordinated breathing, our study compared the drug mass delivered per MDI actuation after a two-second delay by four VHCs: one collapsible device made from paperboard (LiteAire®, Thayer Medical), and three devices made from rigid polymer (AeroChamber Max® and AeroChamber Plus®, Monaghan Medical Corp.; and OptiChamber Advantage®, Respironics). Using these results and the unit cost of each VHC, a cost-to-performance ratio was calculated for each device.

Materials and Methods
Five of each of the four VHCs (n=5) were evaluated using a USP throat model attached via 22 mm tubing to a Harvard Apparatus large animal ventilator simulating tidal breathing of 750 mL at 12 breaths/minute and 1:1 I:E. Eight actuations of albuterol sulfate were delivered to each VHC from a pre-primed and shaken MDI canister. After each MDI actuation there was a two-second pause prior to inhalation.

Results
The results are summarized in Table 1. The drug mass per MDI dose delivered by the AeroChamber Max (67 µg/dose) was significantly larger than the LiteAire (55 µg/dose), the OptiChamber Advantage (52 µg/dose), and the AeroChamber Plus (48 µg/dose), which were not significantly different from each other. When device cost was factored in, the LiteAire was significantly more efficient than the other three VHCs, costing $0.05 per µg of drug delivered, compared to $0.16 for the AeroChamber Max, $0.20 for the OptiChamber Advantage, and $0.21 for the AeroChamber Plus.

Conclusions
Under the conditions tested, the AeroChamber Max offered drug mass delivery performance that was significantly higher than the other VHCs. When device cost was considered, the LiteAire yielded significantly lower device cost per drug mass delivered than the three plastic VHCs. This metric may be of importance for short-term VHC applications in which both device cost and performance are of interest.