Aerosol Delivery in a Pediatric Model of Non-Invasive Ventilation
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BACKGROUND
Non-invasive ventilation (NIV) is often used to treat respiratory failure in patients with concomitant need for aerosol delivery. There are extensive data on aerosol delivery for invasive ventilation showing that the vibrating mesh nebulizer (VMN) placed at the ventilator is the most efficient setup, but there are few published studies for NIV. These studies have limitations such as use of a single-limb ventilator circuit, use of only one type of device, use of non-anatomically correct airway models and mostly use of adult models.

Our institution’s intensive care unit uses a double-limb circuit during non-invasive ventilation when transitioning patients from invasive ventilation. Knowing aerosol delivery efficiency of different devices when placed at different locations on the ventilator circuit is clinically relevant.

This in-vitro study used a double-limb circuit NIV and anatomically correct pediatric model, to compare the effect of type of nebulizer and position on aerosol delivery efficiency.

HYPOTHESIS
We hypothesize that during NIV with a double-limb ventilator circuit, use of VMN and placement at the ventilator will result in higher delivery efficiency.

MATERIALS AND METHODS
Breathing model
• Breathing simulator: Tidal volume 200 mL, RR 20 breaths/min (bpm), I:E ratio 1:3, and i-time 0.75s
• Low dead space filter holder (lung dose)
• Anatomically correct head/airway model of a 5-year-old child

Testing Set-up (Figure 2)
• Oro-nasal mask was placed on the head model and connected to the Servo-i ventilator through a double-limb ventilator circuit.
• Ventilator Setting: NIV mode, 15/5 cm H₂O, back up rate 15 bpm
• Aerosol: Albuterol sulfate (2 mg/3mL solution)
• Device: Jet Nebulizer (JN) and Vibrating mesh nebulizer (VMN)
• Position: At the ventilator and before the Y-piece.
• Albuterol concentration measured with spectrophotometry 276nm.

Outcome measure
• Delivery efficiency (lung dose expressed as percentage of the nominal dose).

RESULTS
• The VMN was 3.8- and 4.7-fold more efficient than the JN when placed at the Ventilator and the Y respectively.
• Moving the nebulizers from the Ventilator to the Y increased delivery efficiency by 35% (p = 0.012) and 9% for the VMN and JN respectively.

Figure 3: Aerosol Delivery Efficiency in Double Limb Circuit NIV

CONCLUSION
This study showed that the VMN placed before the Y-piece of the double-limb ventilator circuit provides the highest aerosol drug delivery during NIV. Data generated with models of invasive ventilation can’t be extrapolated to NIV models.

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