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Physiological effects of Simeox Airway Clearance Device in healthy adults

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INTRODUCTION

Airway clearance devices (ACDs) assist in mobilizing retained secretions in lung diseases by increasing the velocity of expiratory flow in such a way as to create high shearing forces on the airway walls, and high kinetic energy that enhances the cephalad movement of secretions.

Mucus clearance can be modelled as a two-phase gas-liquid flow mechanism. The oscillatory vibrations on expiration assist in loosening and mobilizing the secretions in three essential ways:

1. by altering the rheological properties of mucus rigidity (sum of viscosity and elasticity) and spinnability (thread forming capacity of mucus);
2. by creating an expiratory flow bias that shears mucus from the airway walls and supports its movement proximally. Peak expiratory flow rate (PEFR) must exceed 30–60 L·min-1 to overcome the adhesive strength by which the mucus is attached to the interface; and
3. by enhancing ciliary beat frequency. Oscillation frequencies of 11-15Hz increase mucus clearance from 8.2 mm·min-1 to 26 mm·min-1, which corresponds to the ciliary beat frequency.

AIM

Aim of this study was to characterize oscillatory flow and negative expiratory pressure pulses generated by a new ACD (Simeox, PhysioAssist) in healthy subjects.

METHODS

10 healthy adults activated Simeox that generates intermittent pulses of intrapulmonary negative air pressure during non-forced exhalations (4 to 6-second duration). The procedure was repeated twice with 4 settings (25% or 100% power at 6 or 12 Hz frequency). Oscillatory flow (Fig 2) and pressure pulses were measured at the mouth with a flow sensor (TSI, Certifier FA plus) to assess Maximal expiratory flow (MEF), maximal mid-expiratory flow (MMEF), Mean expiratory flow (EFmean), maximal expiratory flow amplitude (MEFamp), peak of negative expiratory pressure (NEPpeak) and maximal expiratory pressure amplitude (MEPamp).

RESULTS

60% male, 34±12y, FEV1/FVC 90±14%. Data are presented in table 1. MEF (60 to 120 l/min) and MEFamp (70 to 140 l/min) rates supported generation of high airflow velocity during exhalation over power range. Oscillatory flow was maintained at mid-exhalation.

Rising device power from min to max, increased flow and negative pressure by > 50%.

Low variability of data showed high reproducibility of oscillatory flow (Fig 3a and b) and negative pressure pulses generated with Simeox during procedure. Range of pressure pulses was safe (-10 to -60 mbar).

Table 1: Expiratory flow and negative expiratory pressure pulses

Frequency	6 Hz			12 Hz		
Power	25%	100%	P100%-25%	25%	100%	P100%-25%
MEF l/min	71.1±4.9	111.9±3.9	40.8±3.9	62.6±4.7	104.8±3.4	42.2±3.1
MMEF l/min	63.9±4.5	103.6±4.8	39.7±3.5	56.8±3.7	96.6±4.6	39.8±3.3
EFmean l/min	11.1±3.2	21.3±4.7	10.2±3.3	10.7±4.0	22.8±4.0	12.1±4.2
MEFamp l/min	84.6±4.2	134.1±4.9	49.5±2.8	78.1±5.6	129.2±4.5	51.2±3.9
NEPpeak mbar	-26.4±6.3	-43.8±8.8	-17.4±5.8	-24.9±10.4	-44.2±10.9	-19.3±9.0
MEPamp mbar	-23.2±5.0	-37.8±8.8	-14.6±6.4	-22.4±4.1	-34.9±4.3	-12.4±4.0

CONCLUSION

These data suggest that Simeox may be an efficient and secure technology for airway clearance therapy.

Fig 1: test procedure with Simeox

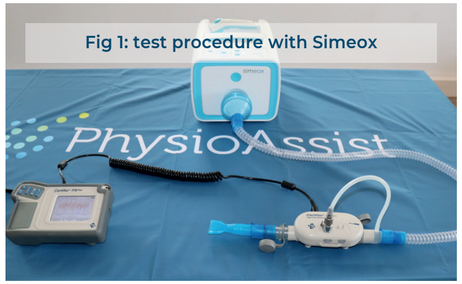

Fig 2: Oscillatory flow during exhalation with Simeox

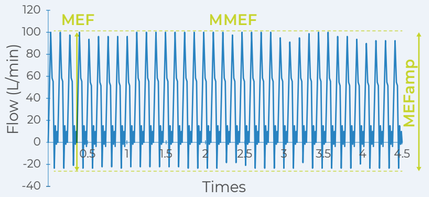

Fig 3a: Maximal flow at 12Hz with maximal power

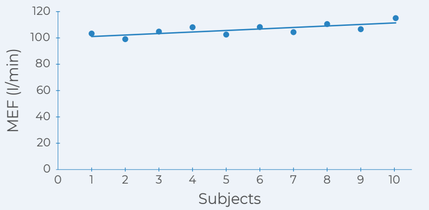

Fig 3b: Maximal flow amplitude at 12Hz with maximal power