RELATIONSHIP BETWEEN PEAK EXPIRATORY AND INSPIRATORY FLOWRATE IN THREE OSCILLATING PEP DEVICES

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Introduction:

The effectiveness of any airway clearance technique depends on the presence of an expiratory flow bias (EFB) to help move secretions cephalad. To achieve an EFB during spontaneous breathing, peak expiratory flow (PEF) must exceed peak inspiratory flow (PIF). Reports in the literature suggest that the PEF needs to be at least 10% greater than the PIF, or the PEF/PIF ratio needs to be greater than 1.1 in order to move secretions toward the oropharynx.[1,2] In this study, a bench model was used with the primary purpose of analyzing PEF/PIF ratio during oscillating positive expiratory pressure (OPEP) therapy in three OPEP devices during simulated breathing: the PocketPEP (D R Burton Healthcare, Farmville, NC), the Aerobika (Monaghan Medical, subsidiary of Trudell Medical International, London, Ontario Canada), and the Acapella (Smiths Medical, Kent, United Kingdom).

Method:

An IngMar Medical ASL 5000 lung simulator, v.3.6 (Pittsburgh, PA) and Hans-Rudolph Smart Lab (Shawnee, KS) were used in the data acquisition and analysis. The ASL 5000 was programmed to simulate OPEP therapy in an adult patient with an inspiratory volume of 1600 ml ± 50 ml. This value represents a deeper breath than normal of approximately three times normal adult tidal volume. Inspiratory time was set to 4 seconds and expiratory time to 4 seconds. Expiratory muscle pressure on the ASL was set for 15 cmH2O. This value represents the mid-point of the therapeutic goal of PEP therapy. Uncompensated residual capacity on the ASL 5000 was set for 1 liter to allow for active exhalation. The PocketPEP was tested with Side 1 facing up while the other two devices were tested at the mid-resistance setting. The full settings including compliance and resistance are shown in figure 1.

Figure 1: ASL 5000 settings
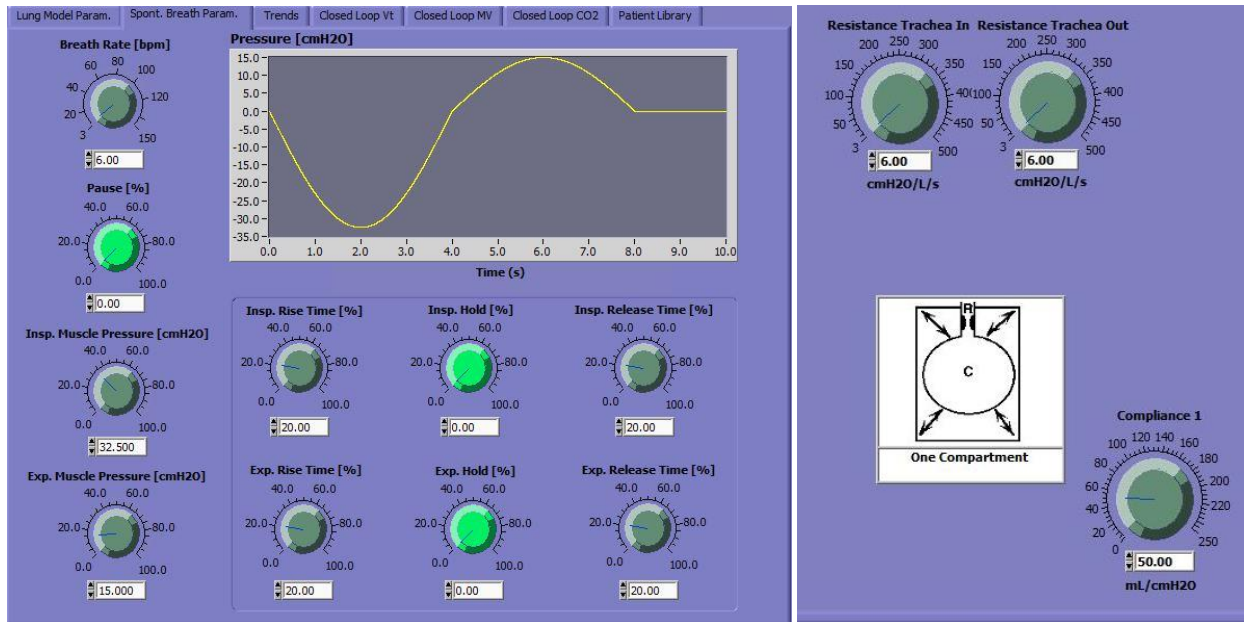
After connecting the OPEP devices to the Smart Lab sensor (Figure 2), the ASL 5000 was started and inspiratory muscle pressure adjusted to achieve an inspiratory volume of 1600 ml ± 50 ml.

Figure 2: ASL5000 Connection to the 3 OPEP Devices

The sensor of the Smart Lab was positioned at the inlet of the ASL 5000 and the different oscillating PEP devices were attached to the distal end of the sensor as shown below:

Aerobika
(Monaghan Medical)

Acapella
(Smiths Medical/
DHD Healthcare Corporation)

PocketPEP
(D•R Burton Healthcare)

Following achievement of the inspiratory volume, the lung simulator ran for a full five minutes before any data was collected. At the end of five minutes, the Smart Lab was started and data from 50 consecutive breaths on each device was collected and stored. The following dependent variables were tested:

1. Peak inspiratory flow (l/m)
2. Peak expiratory flow (l/m)
3. PEF/PIF ratio
4. Oscillatory frequency (hertz)
5. Peak expiratory pressure (cmH2O)
6. Mean expiratory pressure (cmH2O)
7. Pressure amplitude (cmH2O)

Results:

The results of the seven tested variables are shown in figure 3.

Figure 3: Results of Tested Variables

Mean values of 50 breaths collected from the Hans-Rudolph Smart Lab

	Peak Inspiratory flow (l/m)	Peak Expiratory Flow (l/m)	PEF/PIF ratio	Peak Expiratory Pressure (cmH2O)	Mean expiratory Pressure (cmH2O)	Oscillatory frequency (hertz)	Pressure amplitude (cmH2O)
Aerobika	42	57	1.36	20	7	15	21
Acapella	38	60	1.58	18	7	16	20
PocketPEP	31	85	2.74	18	8	15	22

The Values for peak expiratory pressure, mean expiratory pressure, and pressure amplitude were within 11%, 13%, and 10% respectively for all three devices.

Values for oscillatory frequency were within 7% of each other for all three devices.

The PocketPEP has the highest PEF/PIF ratio compared to the other two devices. The PocketPEP produced a PEF/PIF ratio of 2.74 and the Acapella of 1.58. The percent difference of the PocketPEP versus the Acapella is 54%. See Figure 4.

The PEF/PIF ratio for the Aerobika is 1.36. PocketPEP produced a percent difference of 67% over the Aerobika. See Figure 5.

Values for PEF/PIF ratio between the Acapella and Aerobika were more closely aligned with the Acapella producing a PEF/PIF ratio that was a 15% higher than the Aerobika.

Figure 4: Flow-volume loop analysis for PocketPEP and Acapella
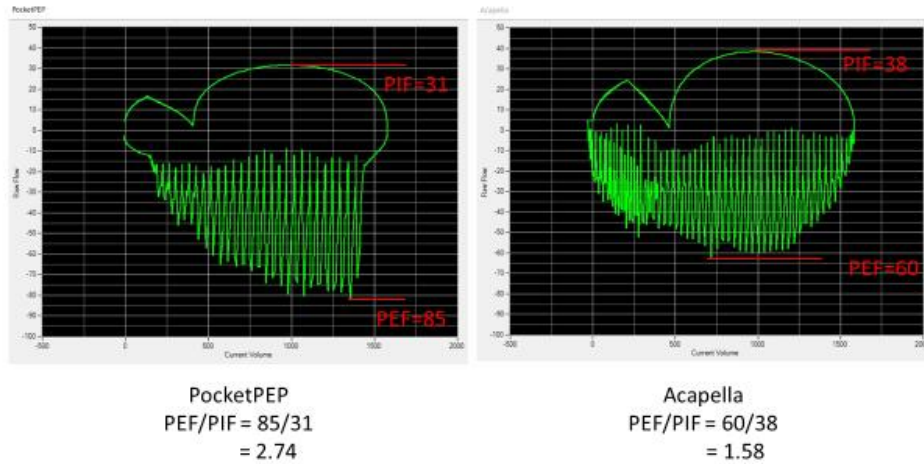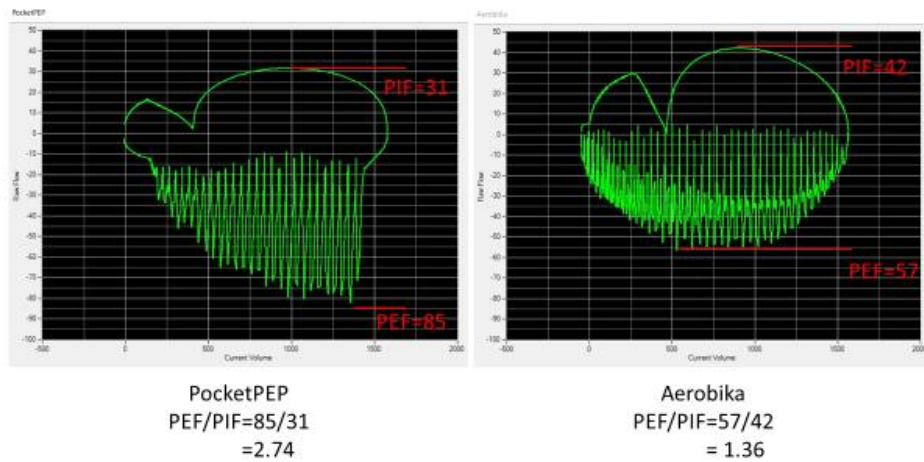

Flow-volume loop analysis of the
PocketPEP vs. Acapella

PocketPEP
PEF/PIF = 85/31
= 2.74

Acapella
PEF/PIF = 60/38
= 1.58

Figure 5: Flow-volume loop analysis for PocketPEP and Aerobika

Flow-volume loop analysis of the
PocketPEP vs. Aerobika

PocketPEP
PEF/PIF=85/31
=2.74

Aerobika
PEF/PIF=57/42
= 1.36

Discussion:

The primary intended use for an oscillatory PEP device is to help clear secretions from airways. One of the major factors in determining secretion movement is the PEF/PIF ratio. Researchers have shown that in order to move secretions cephalad, the PEF/PIF ratio needs to be greater than 1.1, thereby producing an expiratory flow bias.[1,2,3,4] Several other studies have shown the greater the PEF/PIF ratio, the greater the outward displacement of mucus.[5,6,7]

Conclusions:

In this bench study, the PocketPEP, Aerobika, and Acapella produced similar values for peak expiratory pressure, mean expiratory pressure, oscillatory frequency, and pressure amplitude (See Figure 3).

All three devices produced an expiratory flow bias as evidenced by a PEF/PIF ratio of > 1.1. The PocketPEP produced the highest PEF/PIF ratio (2.74) followed by the Acapella (1.58) and the Aerobika (1.36)

References:

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