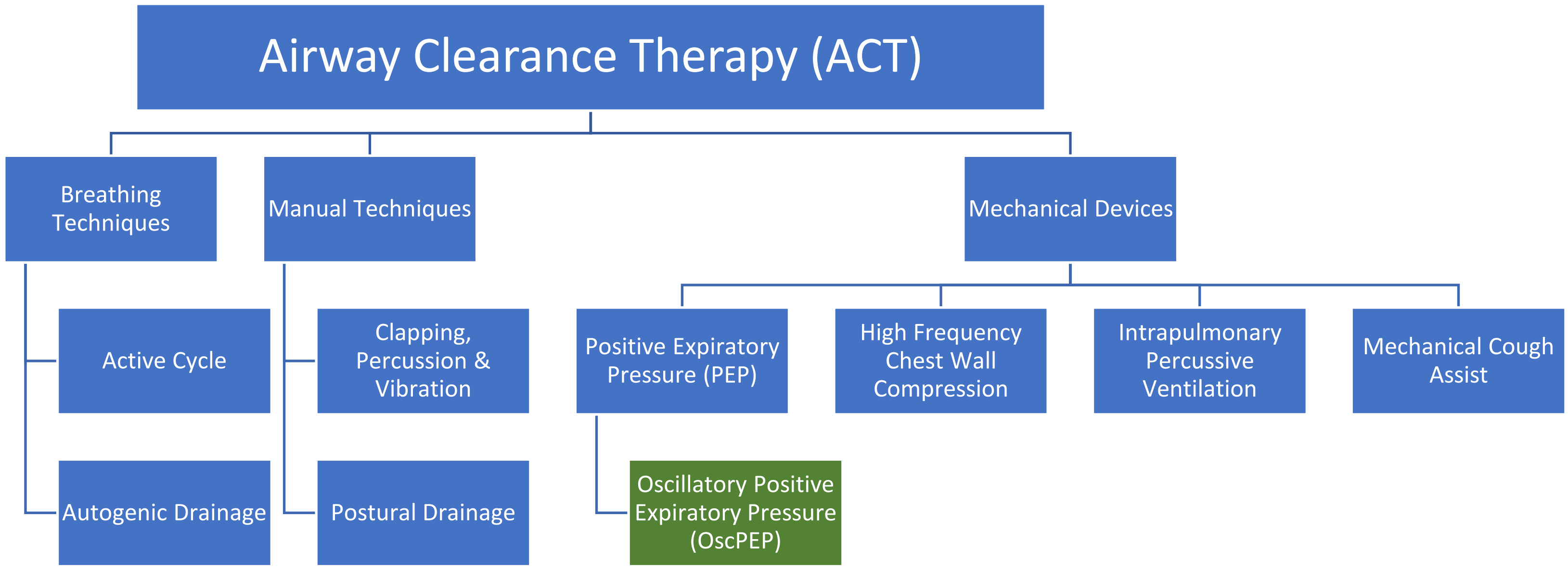
Airway Clearance Therapy (ACT) is indicated for individuals whose function of the mucociliary escalator and/or cough mechanics are altered and whose ability to mobilize and expectorate airways secretions is compromised.



OPEP is a subset of PEP Therapy. OPEP provides positive expiratory pressure (PEP) with flow and pressure oscillations.

VibraPEP®

PEP/OPEP Therapy

How does each parameter effect the OPEP therapy?

PARAMETER

- **Pressure above baseline**
  - Stents the airways open
  - Improves collateral ventilation
  - Requires a prolonged, i.e. ratio of 1:3 or 1:4 to allow more time for gas exchange and collateral ventilation to develop

Therapeutic range

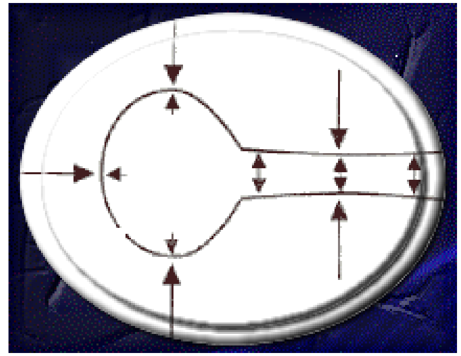
- Low PEP
  (at low lung volume)
  10 –20 cm H2O

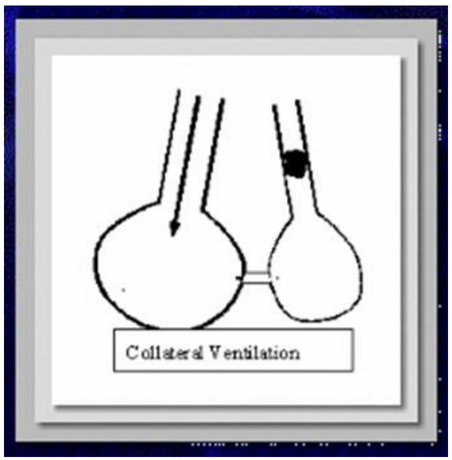
- High PEP
  (at high lung volume)
  >20 –60~80 cm H2O

Mobilize secretion Vs **Re-expand atelectatic area**
Depends on location: > 10 cm H2O
Proximal –high lung vol.
Distal –low lung vol.

PEP Therapy:

Positive pressure allows air to enter peripheral airways via collateral channels permitting air to get behind secretions, moving them towards larger airways where they can easily be expelled, PEP prevents the alveoli from collapsing.



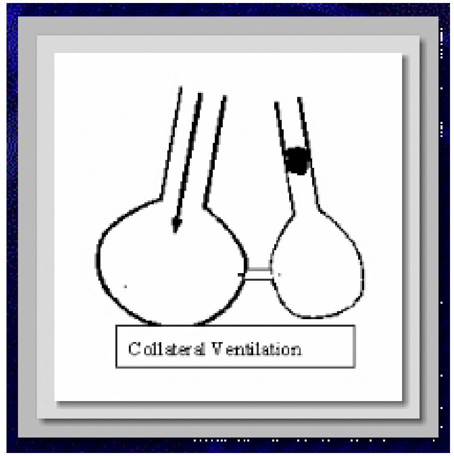


AARC Clinical guidelines for PEP therapy suggest maintaining pressures of 10 – 20 cm H_2O for an I:E ratio of 1:3 to 1:4

This equates to exhalation phase of approximately 3 – 4 seconds

OPEP is PEP with Oscillations

Oscillations of expiratory pressure and airflow, which vibrate the airway walls (loosening mucus), decrease the collapsibility of the airways and accelerate airflow facilitating movement of mucus up the airways and improving lung function and oxygenation.

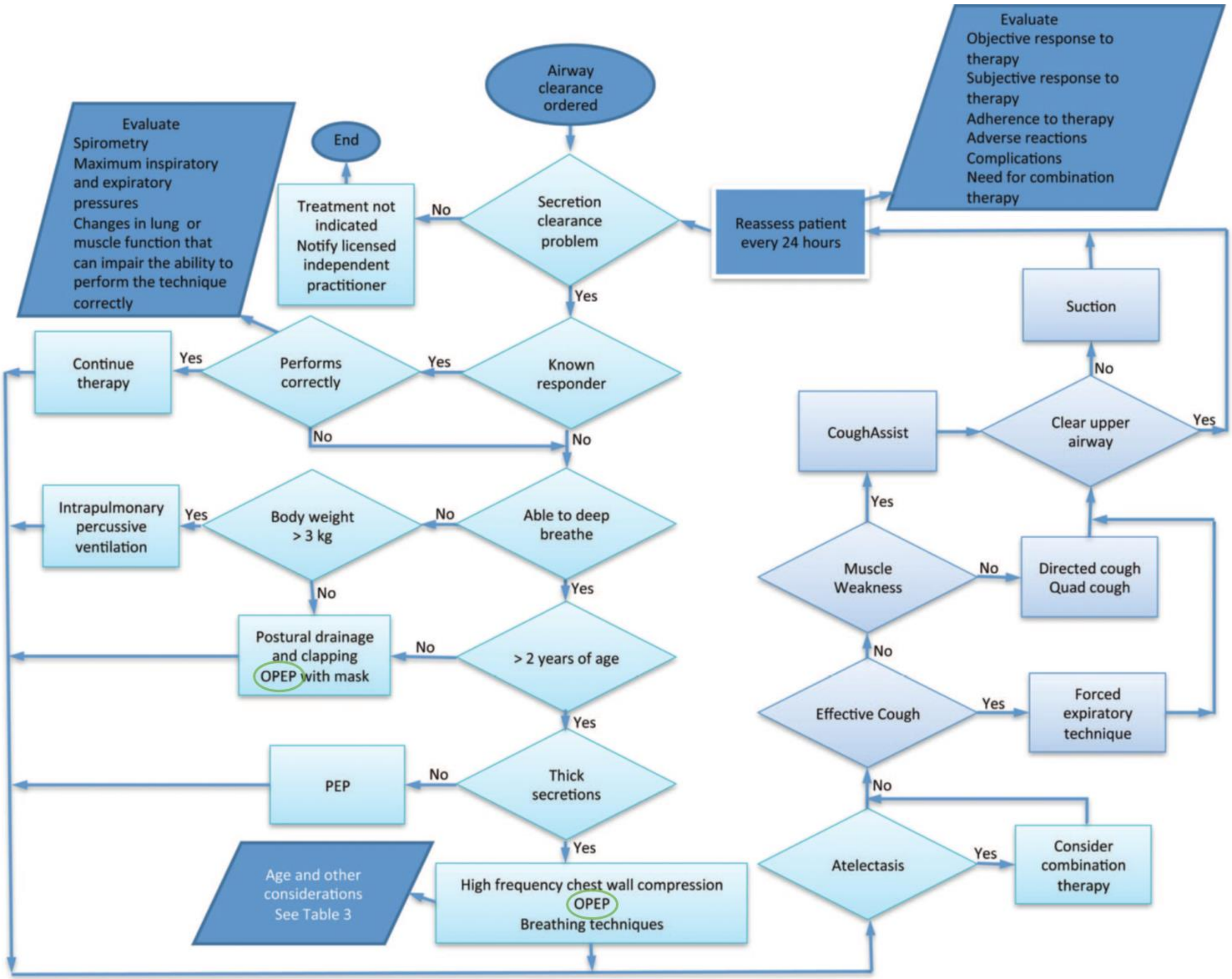


- Provides a percussive effect that disengages mucus from the airway walls
- Pulsates the mucus forward towards the larger airways
- Reduces the visco-elasticity of mucus

The frequency of the vibrations has been reported to range from 10 to 30 Hz

VibraPEP®

Respiratory Therapist Driven Algorithm To Guide Airway Clearance Use

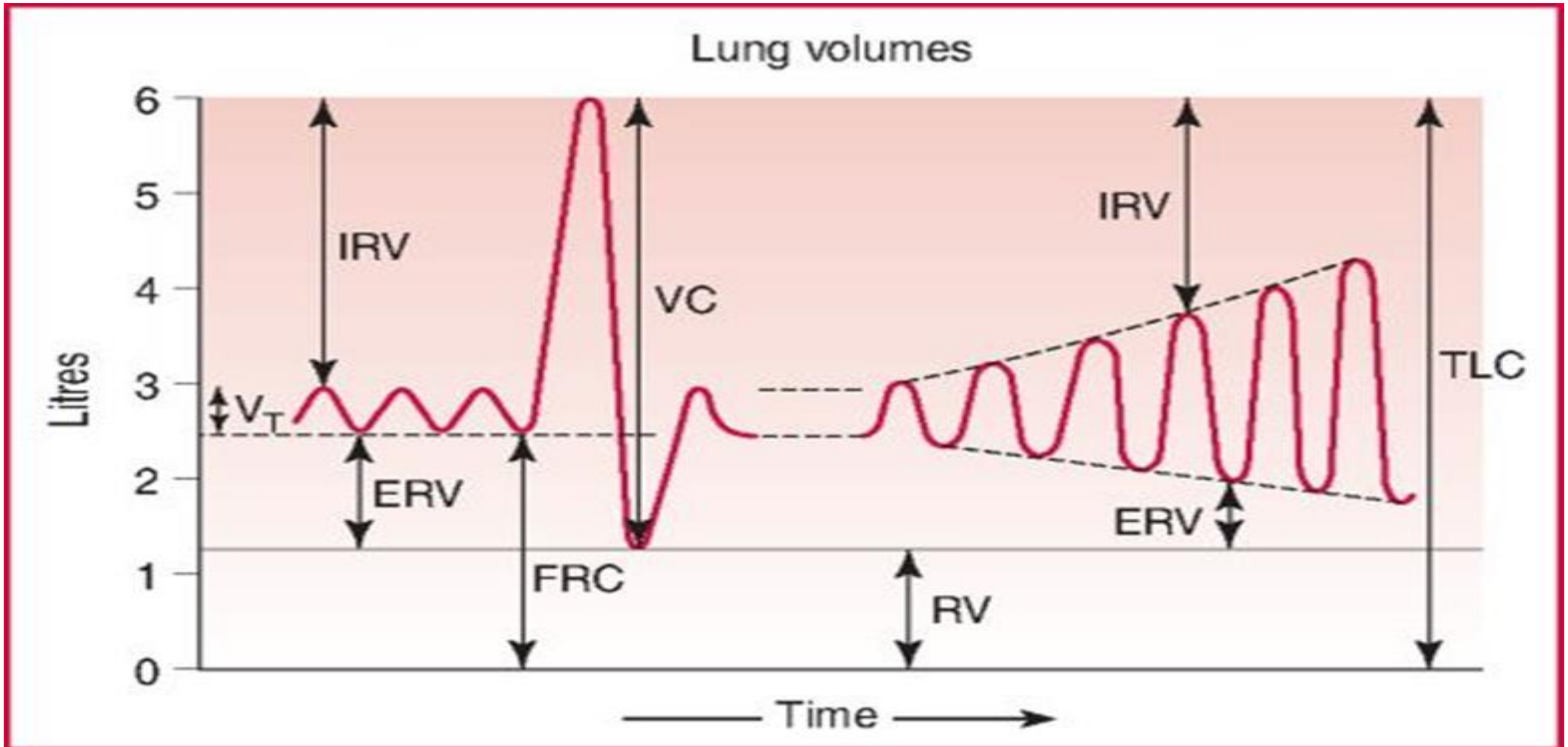


VibraPEP®

The generally accepted procedure for PEP and or OPEP therapy is as follows

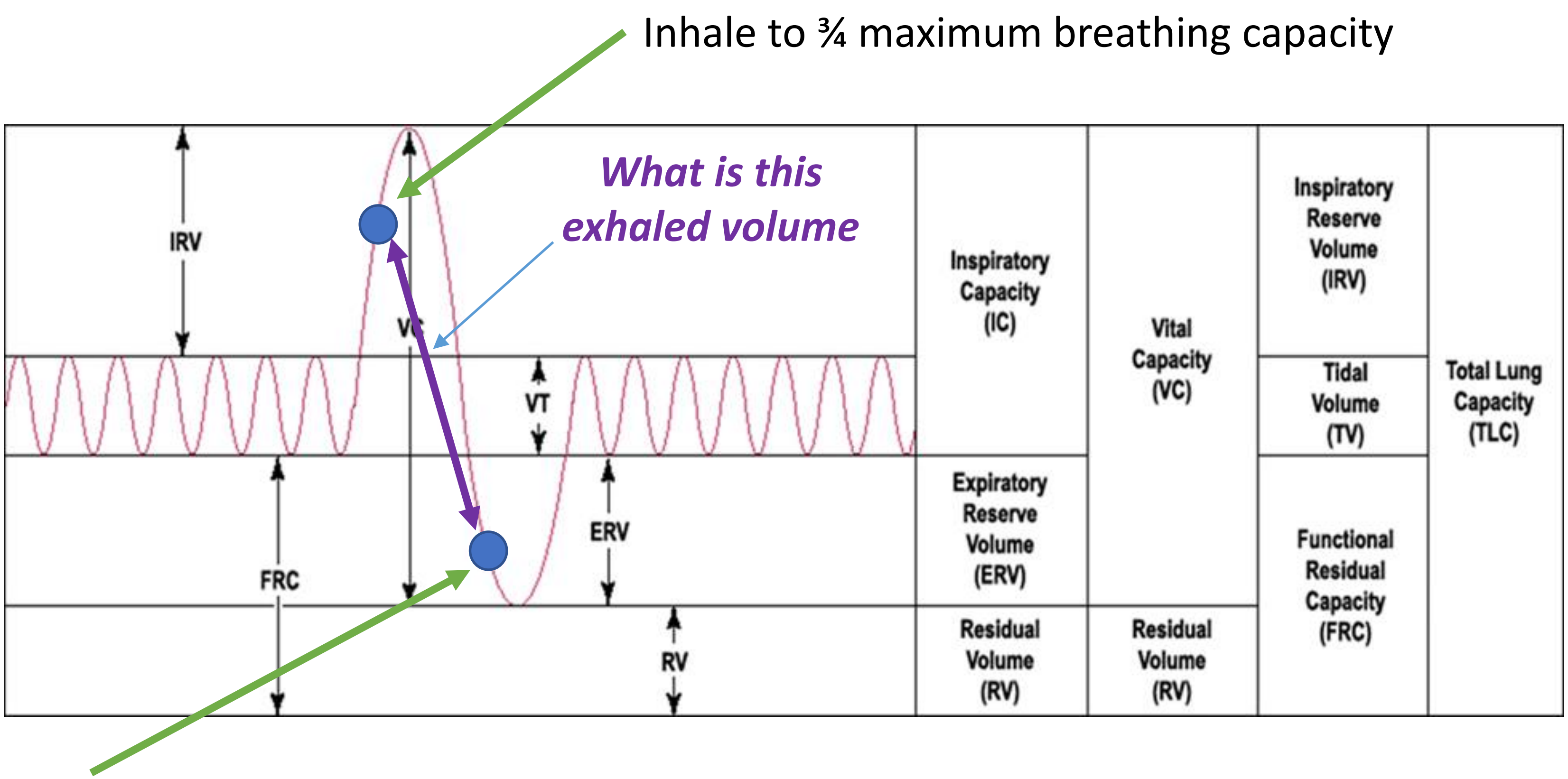
1. Start at resting expiration
2. Patient should inspire a volume of air greater than normal tidal volume, but less than total lung capacity. Instruct patient to slowly inhale to 3/4 maximum breathing capacity.
3. Perform a short breath hold (2 - 3 seconds).
4. Exhale actively, (3 to 4 seconds) but not forcefully, creating a PEP of 10 to 20 cm H_2O during exhalation. Length of inhalation should be approximately one-third of the total breathing cycle (I:E ratio of 1:3 to 1:4)
5. Perform 10 to 20 breaths.

VibraPEP®



V_T(TV)	Tidal volume	Volume of inspired/expired air moving in and out with each breath
IRV ERV	Inspiratory and expiratory reserve volumes	Used when tidal volume increases above that atrest
VC	Vital capacity	Volume that can be inspired/expired after full expiration/inspiration
FRC	Functional residualcapa city	Volume remaining in the lungs at end-expiration;decreases as tidal volume increases
RV	Residual volume	Remains after a maximal expiratory effort;cannot be exhaled
TLC	Total lung capacity	Vital capacity + residual volume

What Is The Exhaled Volume Required To Sustain The OscPEP Therapy?



Exhale actively, (3 to 4 seconds) but not forcefully, creating a PEP of 10 to 20 cm H_2O during exhalation. Length of inhalation should be approximately one-third of the total breathing cycle (I:E ratio of 1:3 to 1:4)

What is the lung capacity that is required of a patient in order to sustain 15 cmH2O (1/2 between 10 and 20) for 3-4 seconds?

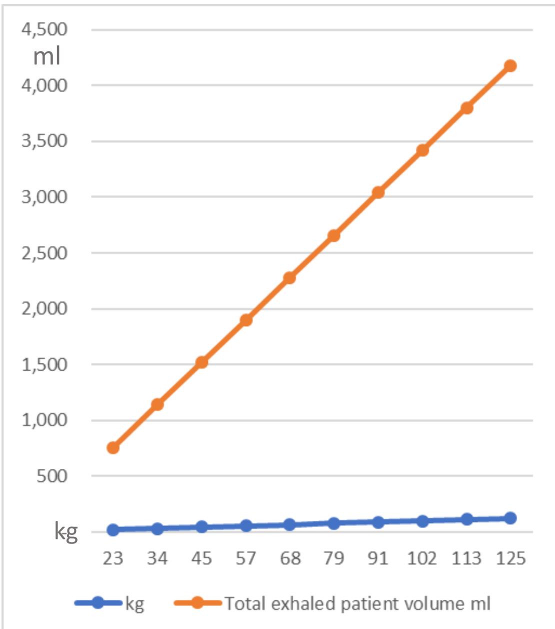
VibraPEP®

Analysis of Tidal Volume and Expiratory Pressure during Oscillatory PEP Therapy in Healthy Subjects

Doug Pursley, M.Ed, RRT-ACCS, FAARC

Respiratory Therapy Vol. 11 No. 2 • Spring 2016

Pursley, in his study of a group of 42 **healthy** subjects performing OPEP therapy found the mean exhaled tidal volume was 33.5 ml/kg PWB (15.4 – 60.7 ml/kg PWB. SD 10.6).



This is an interpretation of Parsley's data. Showing total lung volume per patient weight based on the mean exhaled tidal volume of 33.5 ml/kg

Patient weight		Total exhaled patient volume (ml)
(lbs)	(kg)	
50	23	760
75	34	1,140
100	45	1,520
125	57	1,899
150	68	2,279
175	79	2,659
200	91	3,039
225	102	3,419
250	113	3,799
275	125	4,179

A 175 lb healthy patient should be able to generate a volume of 2.65 l

PWB = Predicted Body Weight

VibraPEP®

One can calculate the maximum sustained flow rate based on the patient volume and exhalation time of 3 to 4 seconds

Patient Weight		Patient Volume	Maximum sustained rate
lbs.	kg	liters	l/min
50	23	0.76	12.66
75	34	1.14	18.99
100	45	1.52	25.33
125	57	1.90	31.66
150	68	2.28	37.99
175	79	2.66	44.32
200	91	3.04	50.65
225	102	3.42	56.98
250	113	3.80	63.31
275	125	4.18	69.65

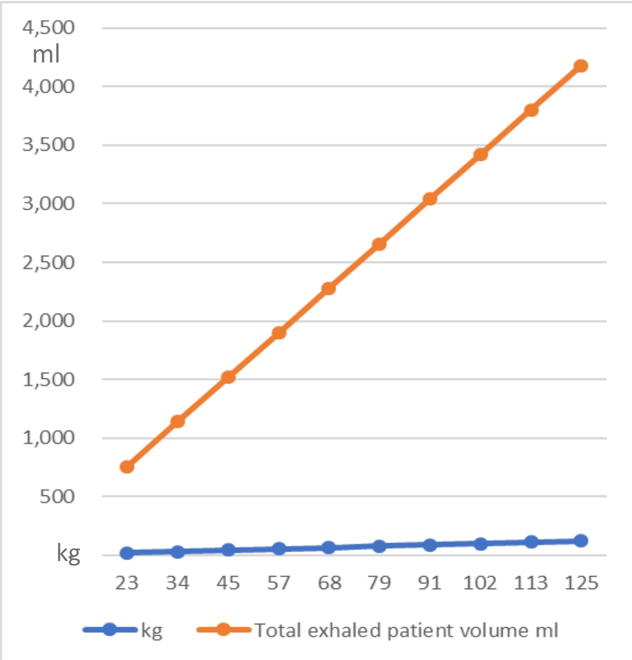
If an OPEP device requires a flow greater than the patients Maximum Sustained Rate, the patient will not be able to achieve the prescribed therapy endpoints

A 175 lb healthy patient should be able to generate a Maximum Sustained flow of 44.32 lpm for 3.5 seconds

Therapy endpoints:
PEP pressure of 15 cmH2O
Slow exhalation over 3.5 seconds

VibraPEP®

What If My Patient Is Not HEALTHY?



Parsley's mean exhaled tidal volume of 33.5 ml/kg was derived from healthy patients.

Indications for Airway Clearance Therapy[8]

Acute Conditions

- Copious secretions
- Inability to mobilize secretions
- Ineffective cough

Chronic Conditions

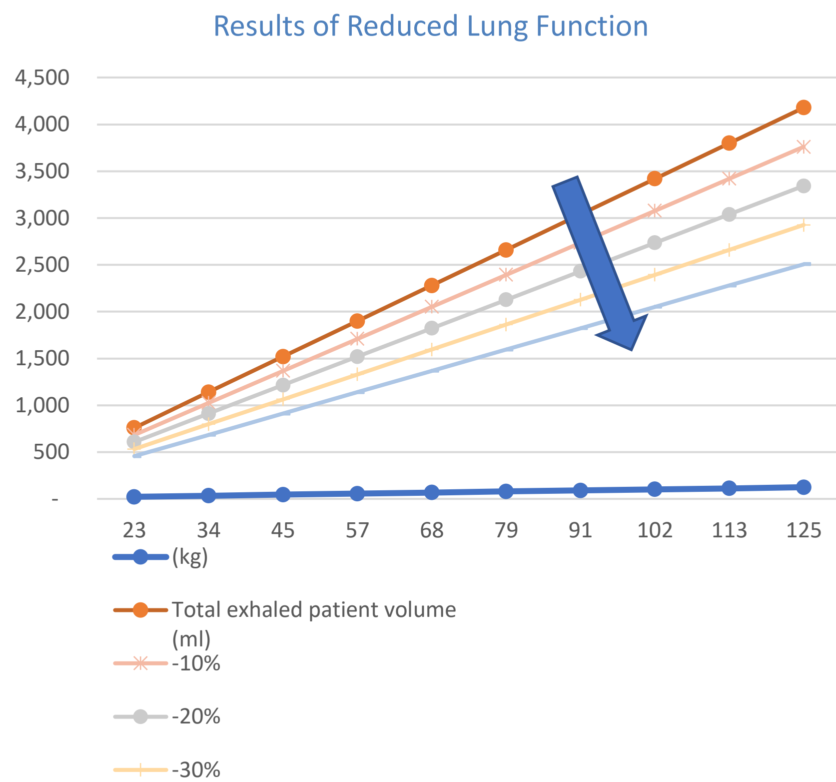
- CF
- Bronchiectasis
- Ciliary dyskinetic syndromes
- COPD patients with retained secretions

Patients that have underlying illnesses that restrict their expiratory flow rates would suffer from a reduced exhaled tidal volume.

Patients are sick because they are retaining secretions thus they are going to have a reduced exhaled tidal volume. If they weren't sick they would not need therapy.

A Reduction In Lung Function Due To Underlying Health Conditions Will Reduce Total Exhaled Patient Volume

			Reduced lung function due to illness			
			-10%	-20%	-30%	-40%
Patient weight		33.5	30.15	26.8	23.45	20.1
(lbs)	(kg)	Total exhaled patient volume (ml)				
50	23	760	684	608	532	456
75	34	1,140	1,026	912	798	684
100	45	1,520	1,368	1,216	1,064	912
125	57	1,899	1,709	1,520	1,330	1,140
150	68	2,279	2,051	1,823	1,596	1,368
175	79	2,659	2,393	2,127	1,861	1,596
200	91	3,039	2,735	2,431	2,127	1,823
225	102	3,419	3,077	2,735	2,393	2,051
250	113	3,799	3,419	3,039	2,659	2,279
275	125	4,179	3,761	3,343	2,925	2,507



The 175 lb patient with a 20% reduction in lung function now has a reduced volume of 2.12 l

Compromised Lung Function Shifts The Total Exhaled Lung Volume Line Down And To The Right

VibraPEP®

Reduced Total Exhaled Patient Volume Will Further Reduce The Maximum Sustained Rate

Patient weight		Maximum Sustained Rate	Reduced lung function due to illness -10%	-20%	-30%	-40%
(lbs)	(kg)	l/min	l/min	l/min	l/min	l/min
50	23	12.66	11.40	10.13	8.86	7.60
75	34	18.99	17.09	15.20	13.30	11.40
100	45	25.33	22.79	20.26	17.73	15.20
125	57	31.66	28.49	25.33	22.16	18.99
150	68	37.99	34.19	30.39	26.59	22.79
175	79	44.32	39.89	35.46	31.02	26.59
200	91	50.65	45.59	40.52	35.46	30.39
225	102	56.98	51.28	45.59	39.89	34.19
250	113	63.31	56.98	50.65	44.32	37.99
275	125	69.65	62.68	55.72	48.75	41.79

The 175 lb patient with a 20% reduction in lung function can now only sustain a flow of 35.46 lpm for 3.5 seconds

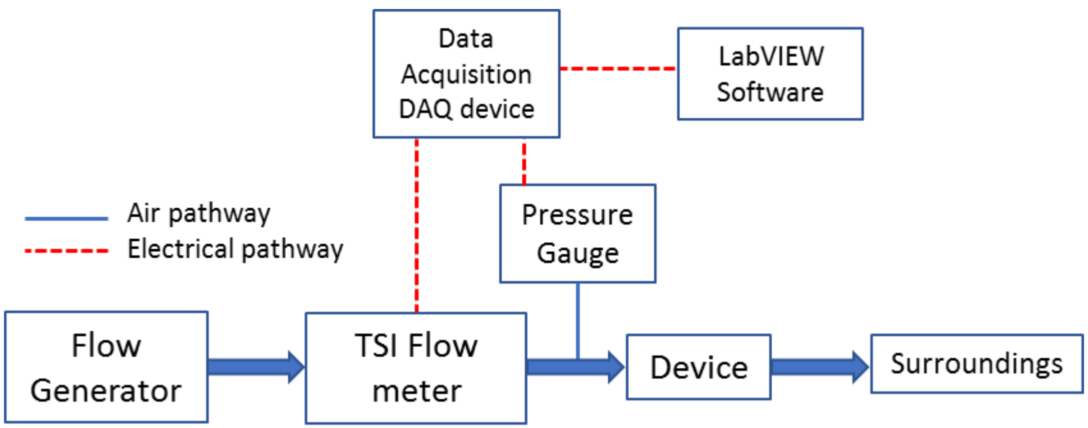
VibraPEP®

How Much Flow Does It Take To Drive An OPEP Device To 15 cmH2O For 3.5 Seconds?

We looked at four differing manufacturers:

Acapella® DH *green*, Smiths Medical
AerobiKa®, Monaghan Medical Corporation
VibraPEP®, Curaplex
vPEP™, D R Burton Healthcare

We set up a process outlined below to acquire data and analyze the results



VibraPEP®

Results

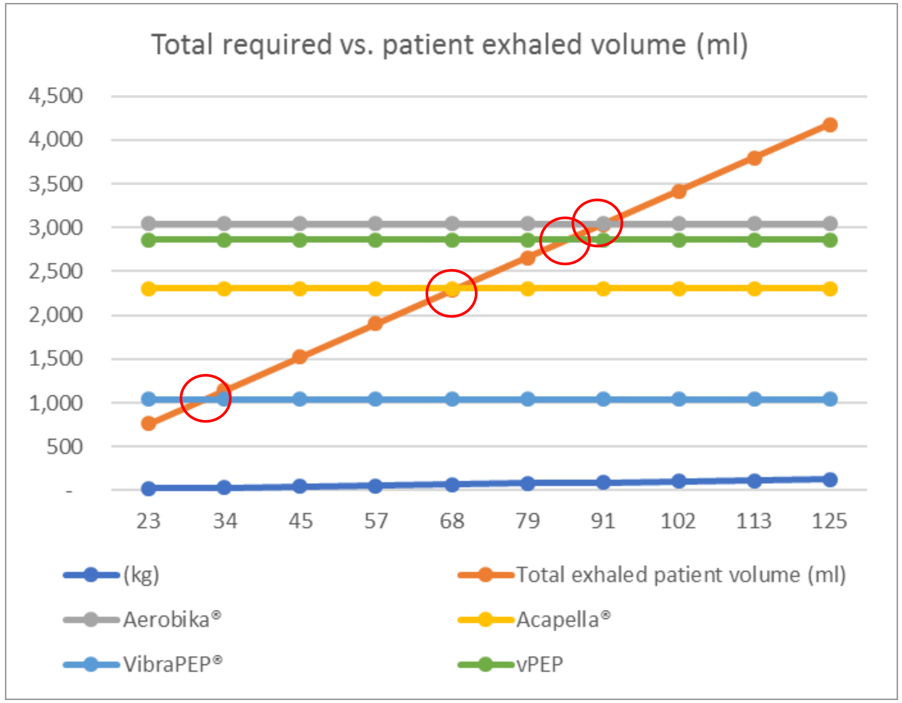
PARAMETER	Aerobika®	Acapella®	VibraPEP®	vPEP
Avg. Pressure (cmH2O):	14.08	14.25	14.62	13.18
Avg. Pressure Amplitude, Peak-to-Peak (cmH2O):	10.65	9.39	10.75	16.97
Frequency (Hz)	16.71	15.72	18.72	14.74
Avg. Flow Rate (lpm)	52.14	39.52	17.78	49.08

Given the average flow rate from the bench study we can calculate the total exhaled volume that the patent would be required to generate to reach the prescribed 15 cmH2O.

Device	Flow to achieve ~ 15 cmH2O		Convert lpm to mL/sec (1 L/min = 16.67 mL/sec)		Seconds of exhalation	Total exhaled volume	
Aerobika®	52.1	lpm	869.2	mL/sec	3.5	3,042	mL
Acapella®	39.5	lpm	658.8	mL/sec	3.5	2,306	mL
VibraPEP®	17.8	lpm	296.4	mL/sec	3.5	1,037	mL
vPEP	49.1	lpm	818.2	mL/sec	3.5	2,864	mL

Compare Patient Available Volume To The Required Device Volume

Patient weight		Total exhaled patient volume (ml)	Total required exhaled volume (ml)			
(lbs)	(kg)		Aerobika®	Acapella®	VibraPEP®	vPEP
50	23	760	3,042	2,306	1,037	2,864
75	34	1,140	3,042	2,306	1,037	2,864
100	45	1,520	3,042	2,306	1,037	2,864
125	57	1,899	3,042	2,306	1,037	2,864
150	68	2,279	3,042	2,306	1,037	2,864
175	79	2,659	3,042	2,306	1,037	2,864
200	91	3,039	3,042	2,306	1,037	2,864
225	102	3,419	3,042	2,306	1,037	2,864
250	113	3,799	3,042	2,306	1,037	2,864
275	125	4,179	3,042	2,306	1,037	2,864

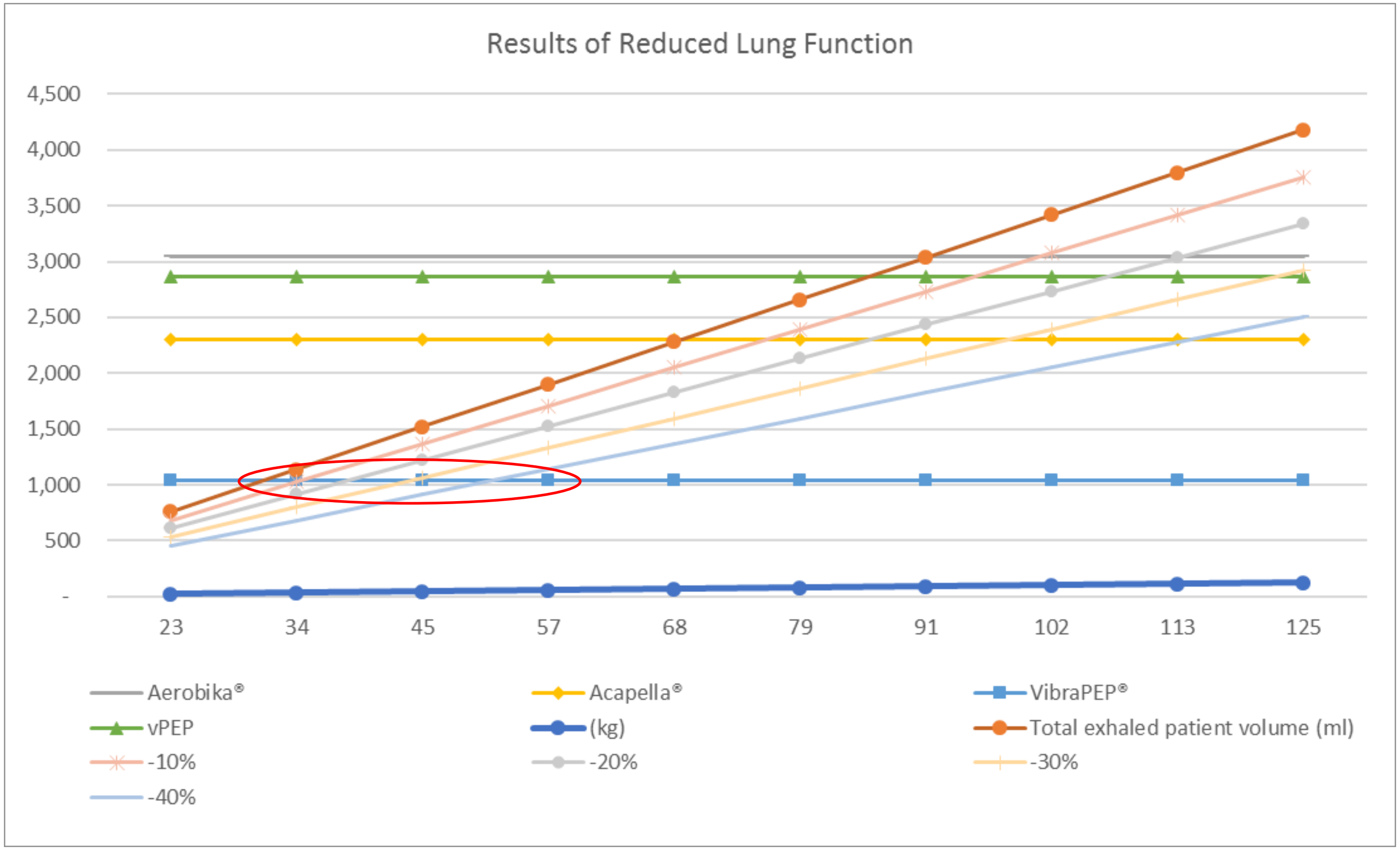


The Patient does not receive therapeutic treatment until the orange line crosses the OPEP line.

The area under the OPEP line but above the Total Exhaled Patient Volume line theoretically show a mismatch between the required volume to perform the therapy correctly and the patient's ability to reach that level. The mismatch between the two values will result in the patient either not meeting the prescribed pressure, not prolonging the breath long enough or both.

VibraPEP®

Patients with compromised lung function have a harder time achieving therapeutic endpoints of 15 cmH2O for 3 to 4 seconds



VibraPEP®

VibraPEP® Converts The Entire Patient Effort Into Therapy

There are differing technologies used to generate OPEP flow interruptions and oscillations. They can be categorized into two groups; *mechanical* and *oscillating valve*.

- *Mechanical devices* use either a fulcrum, (Acapella®), rudder (AerobiKa®) or flipper (D R Burton) that interrupts the patients flow.

- *Oscillating valve* device (VibraPEP®) relies on the reverberation of flow moving through an elastic valve to create PEP and oscillations.

A portion of the patient's flow (effort) when directed through the apparatus is converted, or lost, into work to make the device function. This conversion of work can be compared to heat loss exhibited by electric motors due to inefficiency.

The Oscillating Valve technology is not mechanical so there is NO patient flow diverted to make the system operate.

VibraPEP™

Oscillating Valve Technology converts the entire patient effort into therapy

VibraPEP™

Differentiating Feature Set

- **Higher level of PEP** promotes collateral ventilation by stabilizing and enlarging the airway.
- **Asynchronous Dynamic Oscillations** promote shearing of mucus from the bronchial walls.
- **Device converts the entire breath** into therapy reducing dyspnea
- One device for all patients
- Not position dependent
- Simultaneous Therapy

  A nebulizer “T” adapter allows for the simultaneous administration of aerosol and OPEP therapy.

VibraPEP™

- **Patient Indications**
  - To reduce air trapping in patients with asthma and COPD
  - To aid in mobilization of retained secretions (in cystic fibrosis and chronic bronchitis)
  - To prevent or reverse atelectasis
  - To optimize delivery of bronchodilators in patients receiving bronchial hygiene therapy

VibraPEP™

- **Contraindications**
  - No Absolute Contraindications

  - Relative Contraindications
    - Inability to tolerate increased WOB
    - Increased intracranial pressure
    - Hemodynamic instability
    - Oral or facial trauma or surgery

References

Ewart W. The treatment of bronchiectasis and of chronic bronchial affections by posture and by respiratory exercises. Lancet 1901;2: 70–72

Falk M, Kelstrup M, Andersen JB, et al. Improving the ketchup bottle method with positive expiratory pressure, PEP, in cystic fibrosis. Eur J Respir Dis 1984; 65: 423± 432

AARC Clinical Practice Guideline, May 1993 issue of RESPIRATORY CARE [Respir Care 1993;38(5):516–521]

Altaus P 1989. The bronchial hygiene assisted by the flutter VRP1 (Module regulator of a positive pressure oscillation on expiration). Eur Respir J 2 (Suppl 8): 693.

Volsko T, DiFiore J, Chatburn RL. Performance comparison of two oscillating positive expiratory pressure devices: Acapella versus flutter. Respir Care . 2003;48(2):124–130.

David L. Vines, Donna D. Gardner, Egan's Fundamentals of Respiratory Care, 11 Edition, Chapter 43 page 981

Ramos EM, Ramos D, Iyomasa DM, Moreira GL, Melegati KC, Vanderlei LC, Jardim JR, Oliveira AS, Influence that oscillating positive expiratory pressure using predetermined expiratory pressures has on the viscosity and transportability of sputum in patients with bronchiectasis, J Bras Pneumol. 2009 Dec;35(12):1190-7.

Fagevik Olsén M, Lannefors L, Westerdahl E. Positive expiratory pressure - Common clinical applications and physiological effects, Respir Med. 2015 Mar;109(3):297-307. doi: 10.1016/j.rmed.2014.11.003. Epub 2014 Nov 12.

Claudio Tantucci, Review Article Expiratory Flow Limitation Definition, Mechanisms, Methods, and Significance, Pulmonary Medicine Volume 2013 (2013), Article ID 749860, 6 pages

Doug Pursley, Analysis of Tidal Volume and Expiratory Pressure during Oscillatory PEP Therapy in Healthy Subjects, Respiratory Therapy Vol. 11 No. 2 n Spring 2016

VibraPEP®