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sense and simplicity

Clearing the Air on Secretion Management

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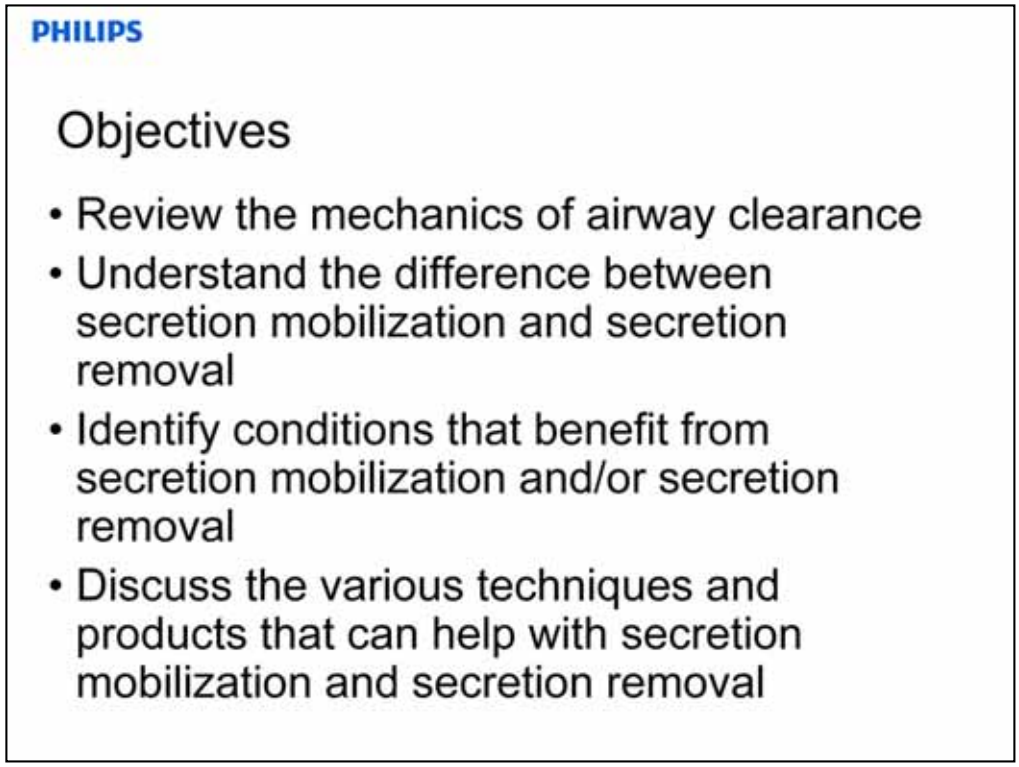
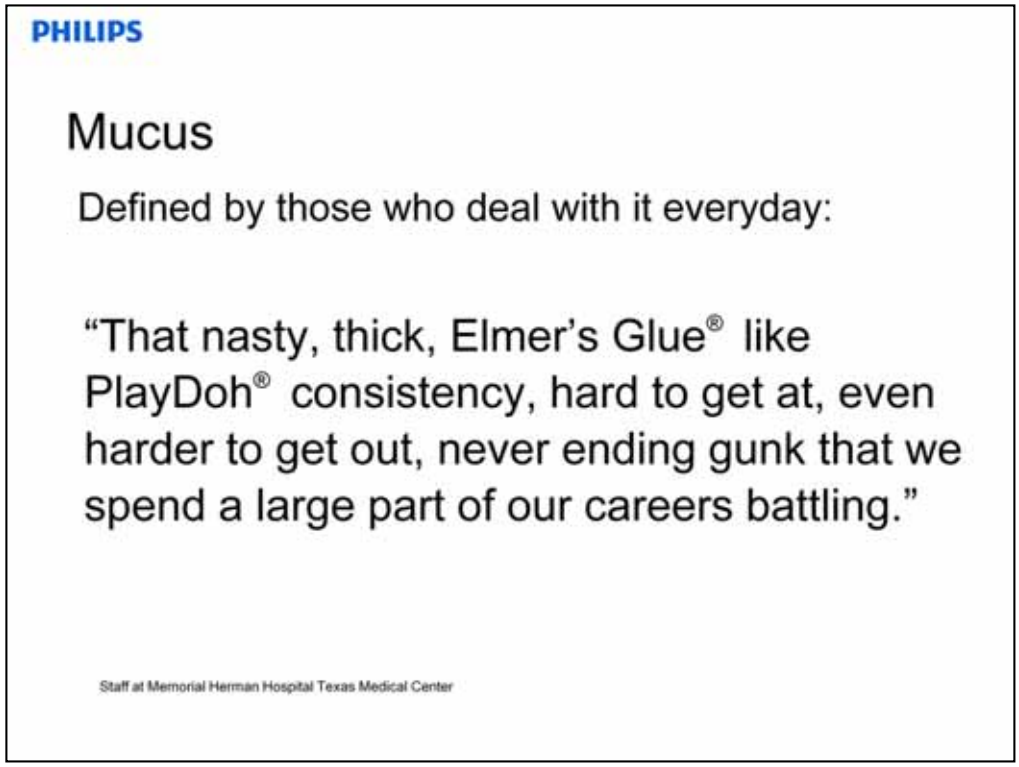


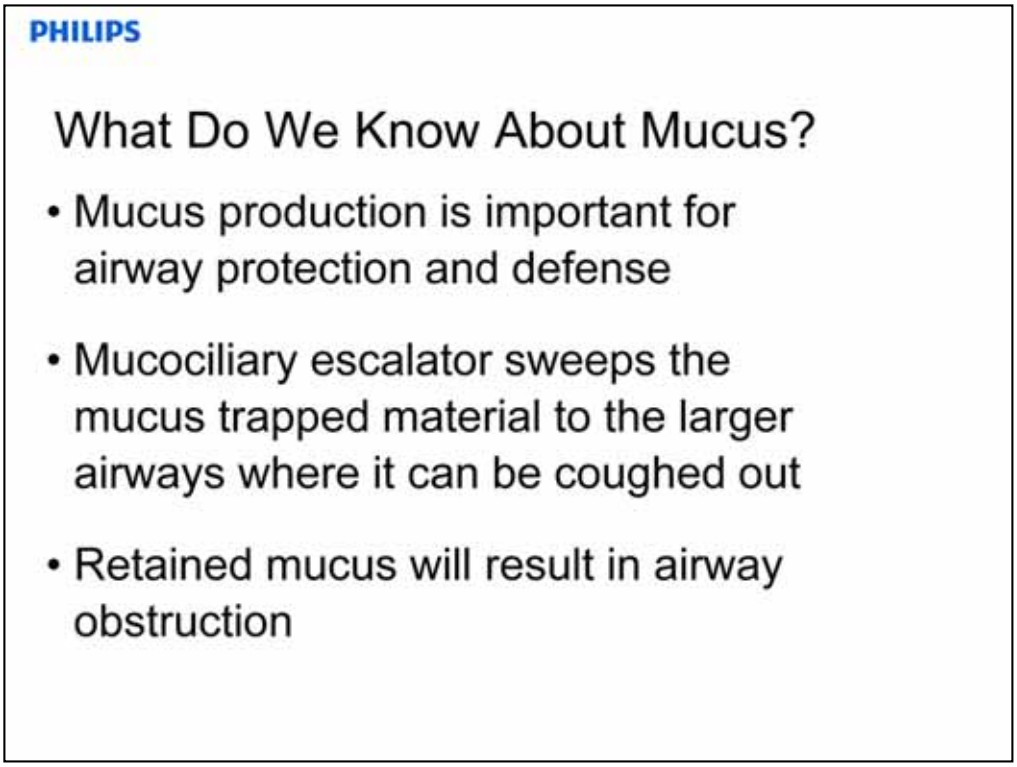
The objectives of this presentation are to

1. Review the mechanics of airway clearance
2. Understand the difference between secretion mobilization and secretion clearance
3. Identify conditions that benefit from secretion mobilization and/or airway clearance
4. Examine techniques for secretion mobilization and airway clearance

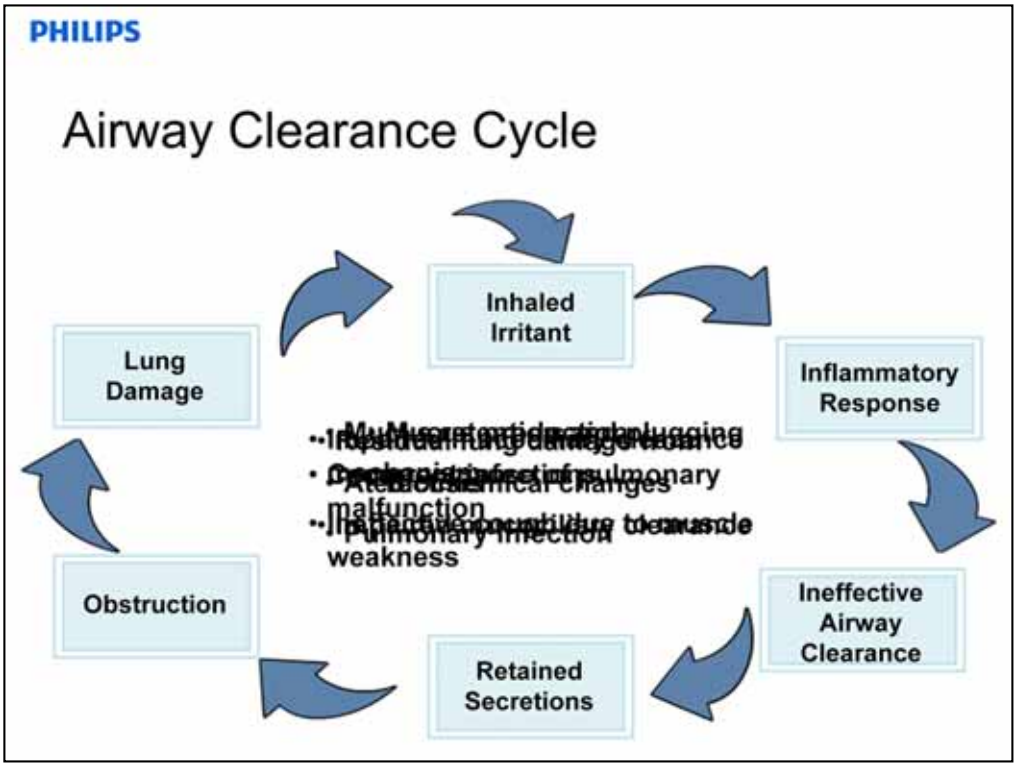


Mucus as defined by the staff at Memorial Herman Hospital is

“That nasty, thick, Elmer’s Glue® like PlayDoh® consistency, hard to get at, even harder to get out, never ending gunk that we spend a large part of our careers battling”



So what do we know about mucus? The lining of the airways normally produces small amounts of mucus, which traps foreign matter. This is important for normal airway defense and protection. The mucociliary escalator sweeps the the mucus to the larger airways where it can be coughed out. If mucus is allowed to accumulate and become thick and excessive, it can result in airway obstruction.



Retained secretions create a vicious cycle of lung damage in a patient that is unable to clear them.

When an irritant is inhaled, the lungs' defense mechanisms are set in motion.

An inflammatory response occurs, in which biochemical reactions take place (including release of white blood cells and water into the area), producing excess mucus to catch and eliminate the irritant or bacteria from the lung.

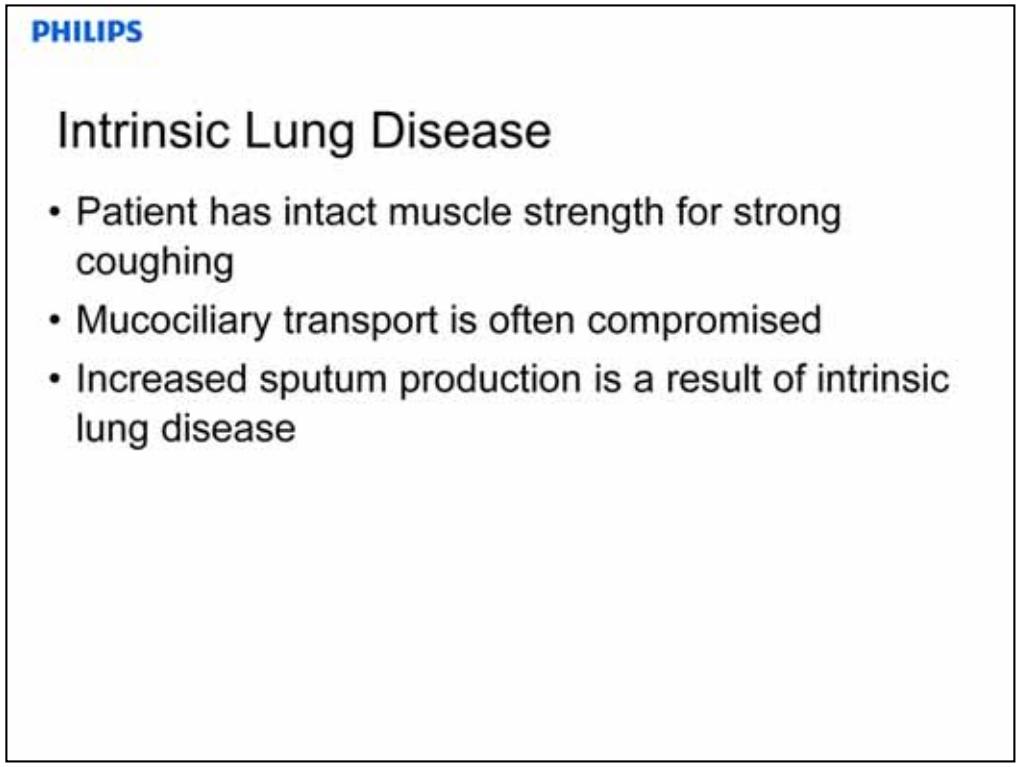
When the mucus cannot be mobilized and removed, secretions are retained.

Plugging of the airways leads to atelectasis (at-tel-eck-ta-sis collapse of the airway) pneumonia and a ventilation-perfusion mismatch.

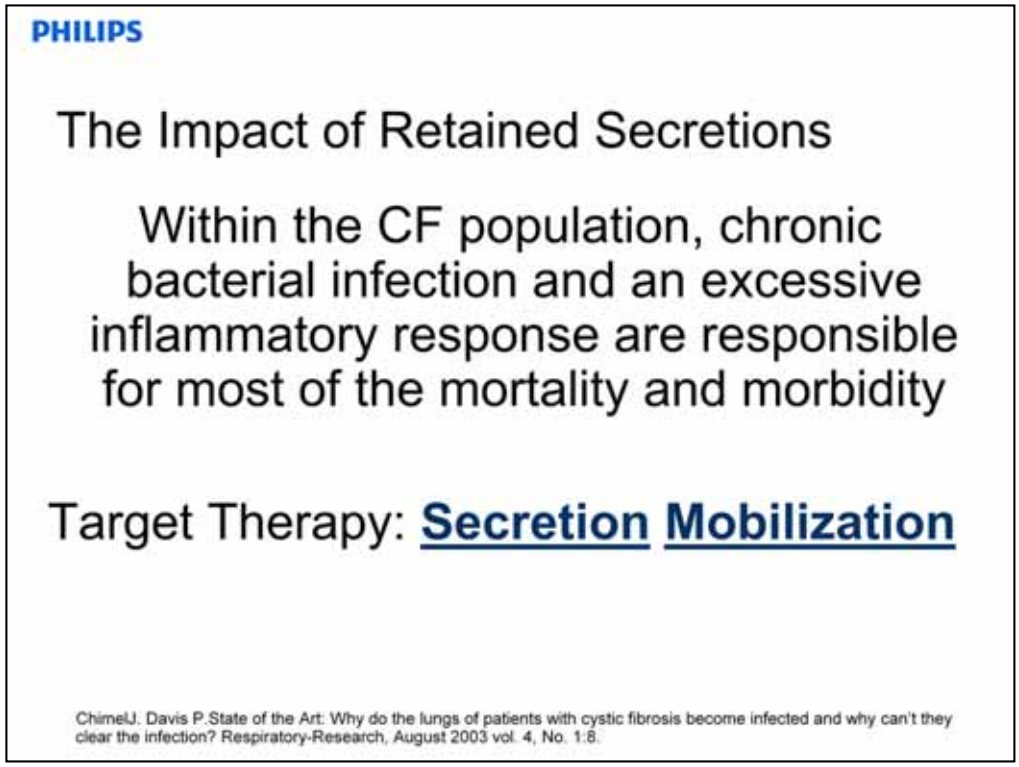
Inflammation and infections cause damage to the airways with changes in the lining of the airways. This injury is the beginning of a cycle in which your airways slowly lose their ability to clear out mucus.

In recent years, both new technologies and more advanced technologies have been developed to increase comfort and effectiveness of airway clearance for the majority of patients. Due to the number of products and techniques that are said to provide airway clearance, determining the most appropriate treatment can be confusing.

Patients that are in danger of retaining secretions can be grouped into 2 disease categories. The first group are those with intrinsic lung disease such as cystic fibrosis, chronic obstructive pulmonary disease and bronchiectasis. The second group are those who have restrictive lung disease with muscle weakness. Many neuromuscular diseases such as ALS, muscular dystrophy, and multiple sclerosis belong in this category. Both spinal cord injury and stroke patients also share this same risk. First lets talk about Instrinsic lung disease.

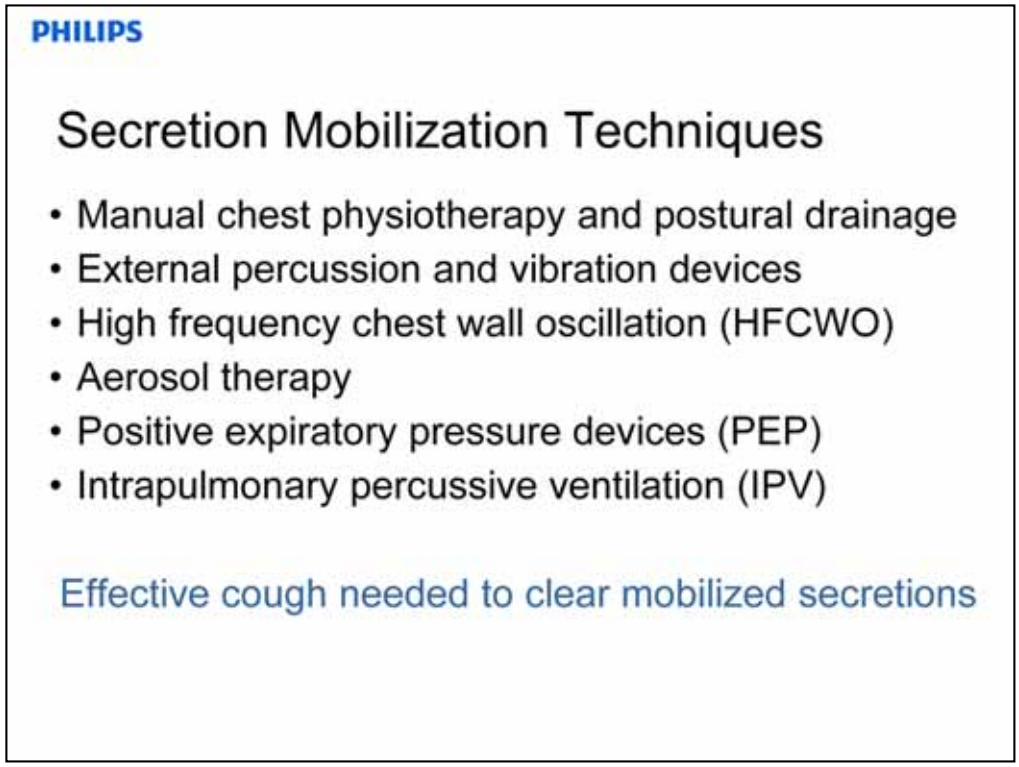


Patients suffering from intrinsic lung disease have the muscle strength for strong coughing but have thick secretions causing the mucociliary transport not to function effectively. This leads to mucus build up in the lower airways.



Within the cystic fibrosis population, chronic bacterial infections and excessive inflammatory response are responsible for most of the mortality and morbidity.

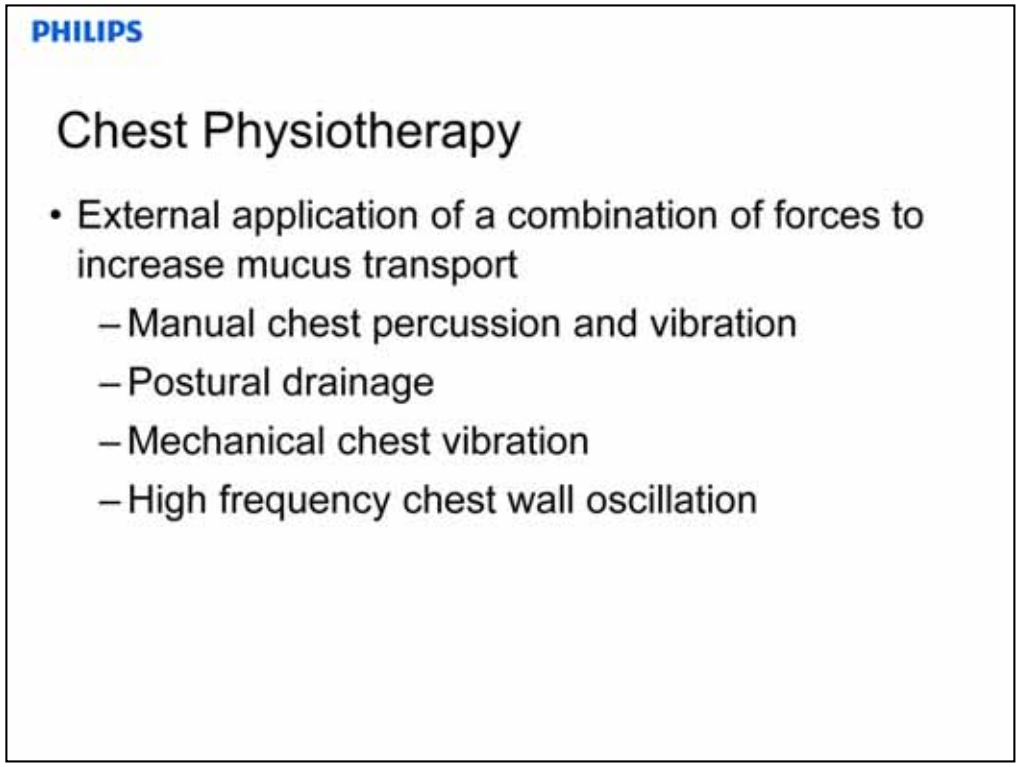
Target therapy is secretion mobilization.



There are several different techniques that help mobilize and loosen secretions. Those include:

- Manual CPT and Postural Drainage
- External Percussion and Vibration Devices
- High Frequency Chest Wall Oscillation (hfcwo)
- Aerosol Therapy
- Positive Expiratory Pressure Devices (PEP)
- Intrapulmonary Percussive Ventilation (IPV)

With all these techniques an effective cough is needed to clear the mobilized secretions.



Chest Physiotherapy is defined as the external application of a combination of forces to increase mucus transport that includes manual chest percussion and vibration, postural drainage, mechanical chest vibration and a newer technology called high frequency chest wall oscillation. This type of device employs the use of a air pulse generator which rapidly fills and deflates a vest.

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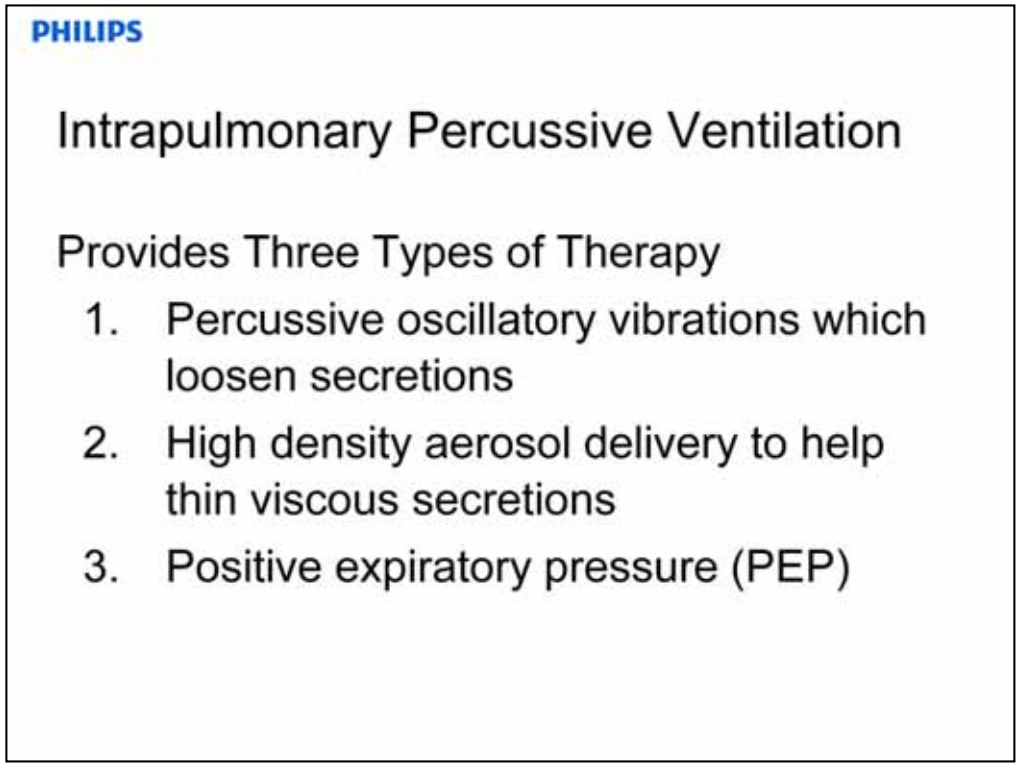
Positive Expiratory Pressure (PEP)

An airway mobilization device that retards expiratory flow and increases expiratory pressure in the airway, opens airways and promotes mucus clearance.

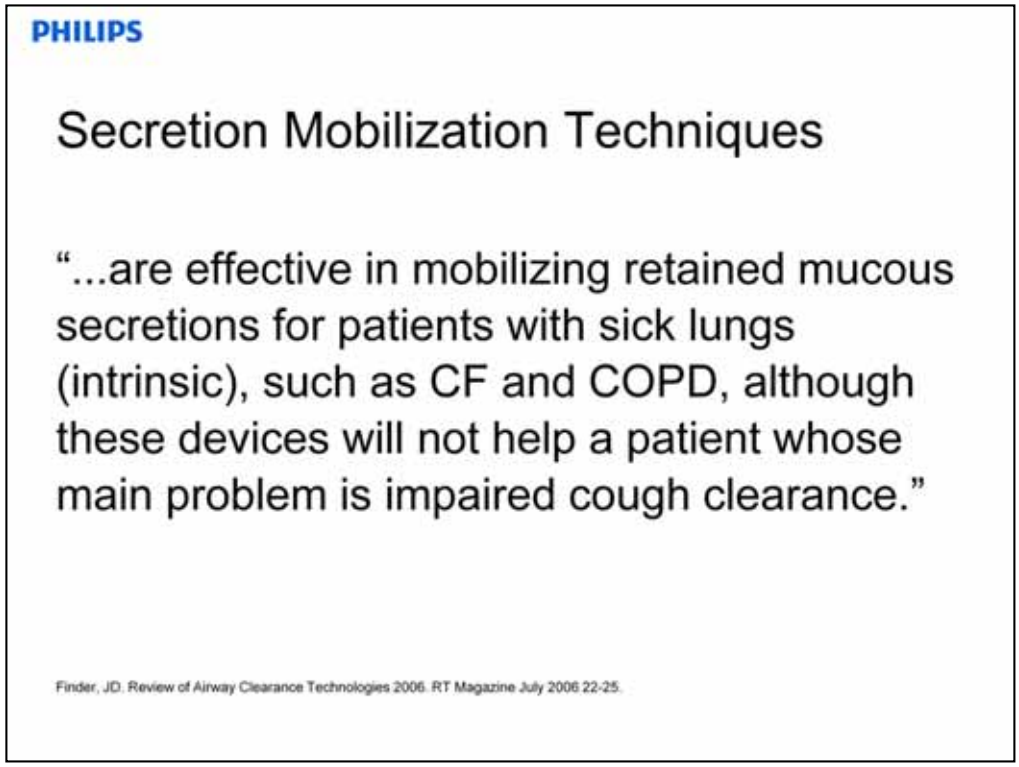
- Oscillating Positive Expiratory Pressure


Another mode of therapy for secretion mobilization is PEP or Positive Expiratory Pressure. PEP devices retard expiratory flow, increasing pressures in the airway. This increase in pressure results in opening airways and promoting mucus clearance.

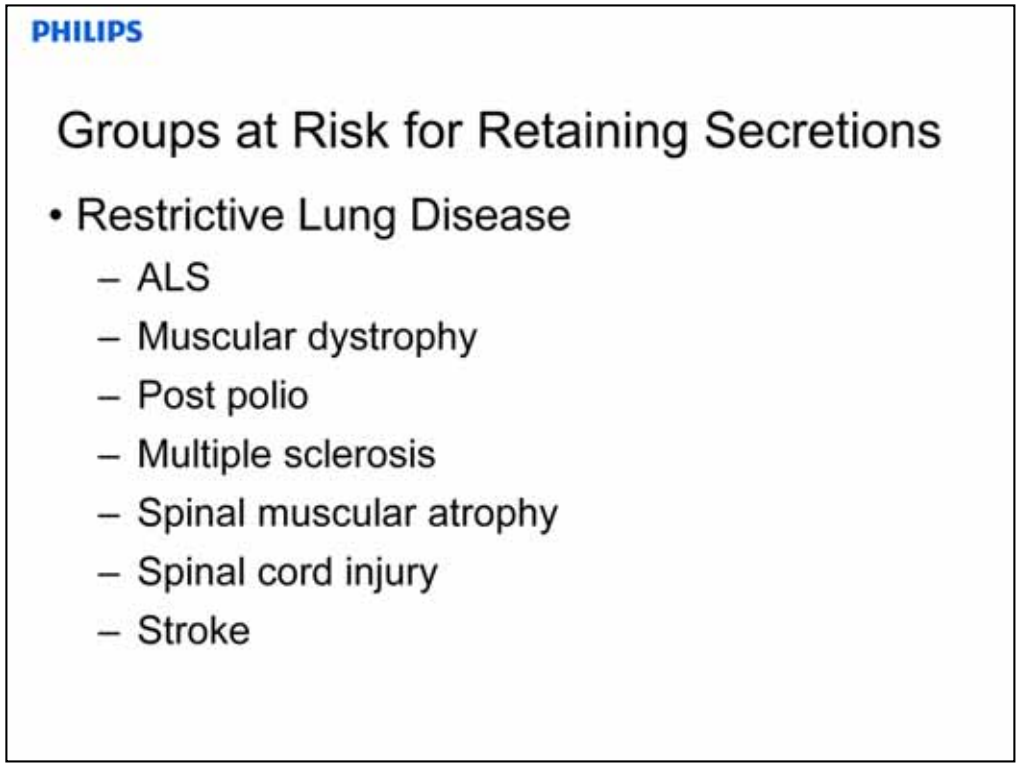
Oscillating Positive Expiratory Pressure devices combine the benefits of PEP devices and airway vibrations to mobilize secretions.



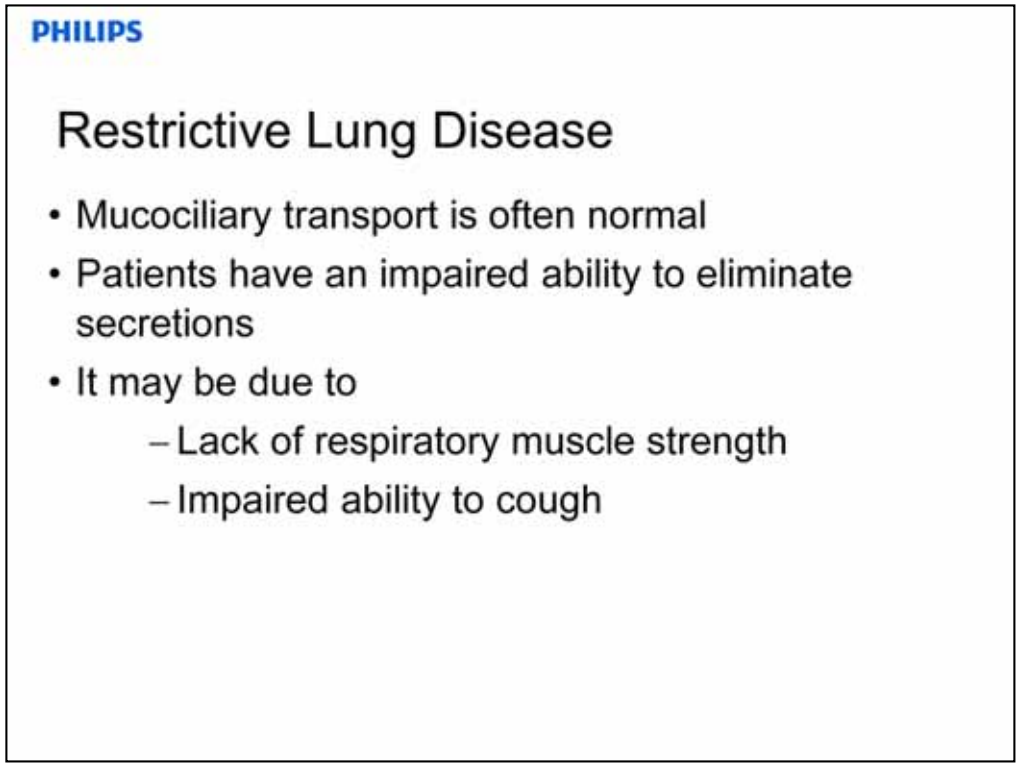
Intrapulmonary Percussive Ventilation or IPV can be a versatile treatment combining PEP to help open distal airways, oscillatory vibrations, and high density aerosol to help loosen secretions and move them to the central airways where they then need to be coughed out.



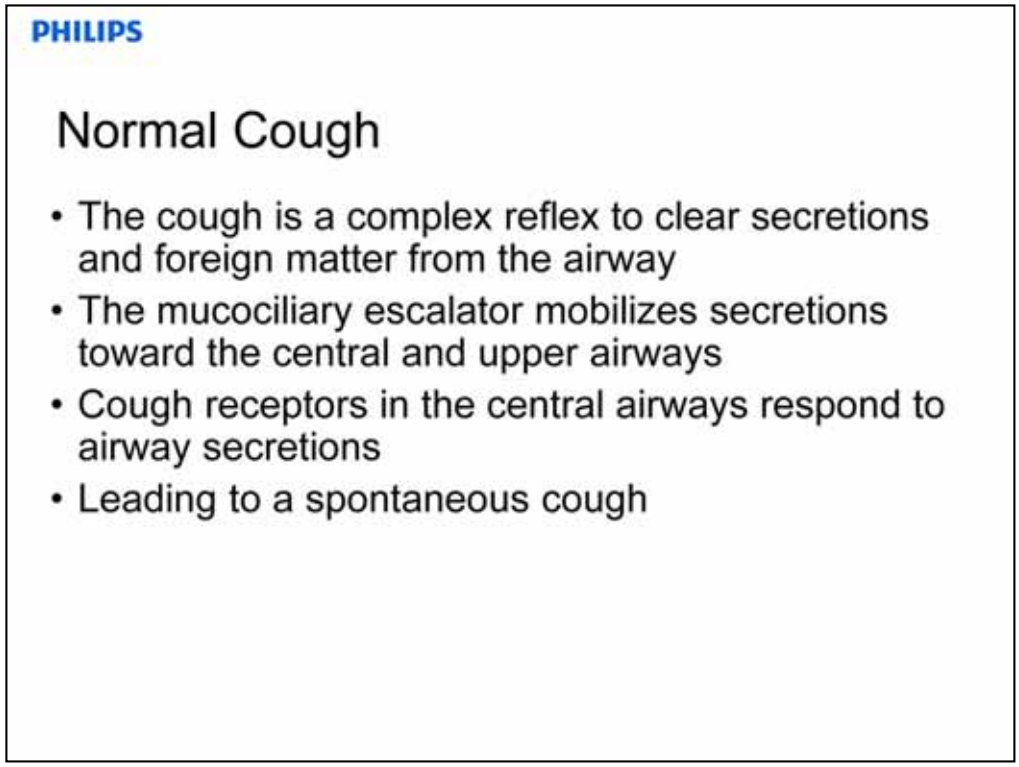
Secretion mobilization techniques according to Dr Jonathan Finder are, "Effective in mobilizing retained mucous secretions for patients with sick lungs (intrinsic), such as CF and COPD, although these devices will not help a patient whose main problem is impaired cough clearance."



I described earlier that patients who are in danger of retaining secretions can be grouped into 2 disease categories. We will discuss the second group which are those who have restrictive lung disease with muscle weakness. Many neuromuscular diseases such as ALS, muscular dystrophy, and multiple sclerosis belong in this category. Both spinal cord injury and stroke patients also share this same risk.



Patients suffering from restrictive lung disease have the inability to eliminate their secretions. This maybe due to lack of muscle strength to generate a cough or an impaired ability to cough. Often with these types of patients the mucociliary transport is normal but increased sputum production id due to the inability to effectively eliminate secretions.

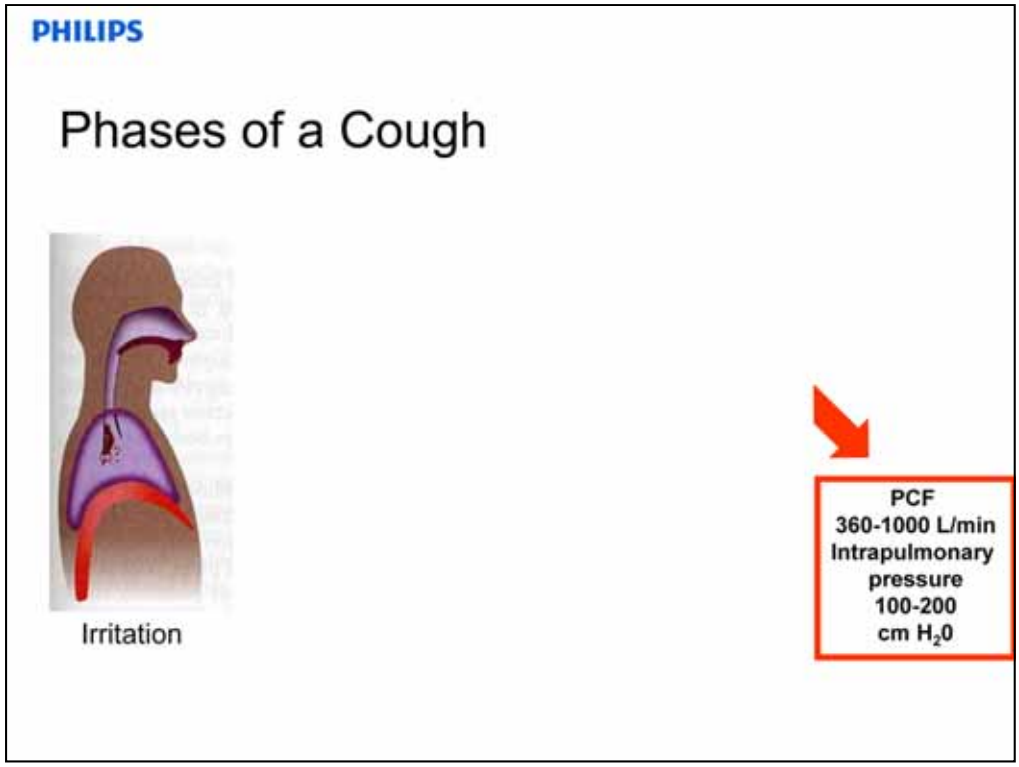


To better understand the therapies that are available to aid patients with ineffective coughs, we will analyze the function of a normal cough.

The cough is a complex reflex to clear secretions and foreign matter from the airway. The mucociliary escalator mobilizes secretions toward the central and upper airways.

Cough receptors in the central airways respond to airway secretions

Leading to a spontaneous cough



There are four phases to the normal cough.

In the first phase, irritant receptors in the upper airway detect foreign matter to be expelled.

The second phase involves a deep breath bringing in air beyond the point of the irritant,

In the third phase, the glottis closes and we compress the air in our lungs with our chest and abdominal muscles.

The last phase is the expulsive phase. As we open our glottis, this allow for the explosive release of the air in our lungs and mobilization of the irritant.

Spontaneous Peak cough flows can approach 1000 L/min and intrapulmonary pressures can reach between 100 and 200 cm H_20.

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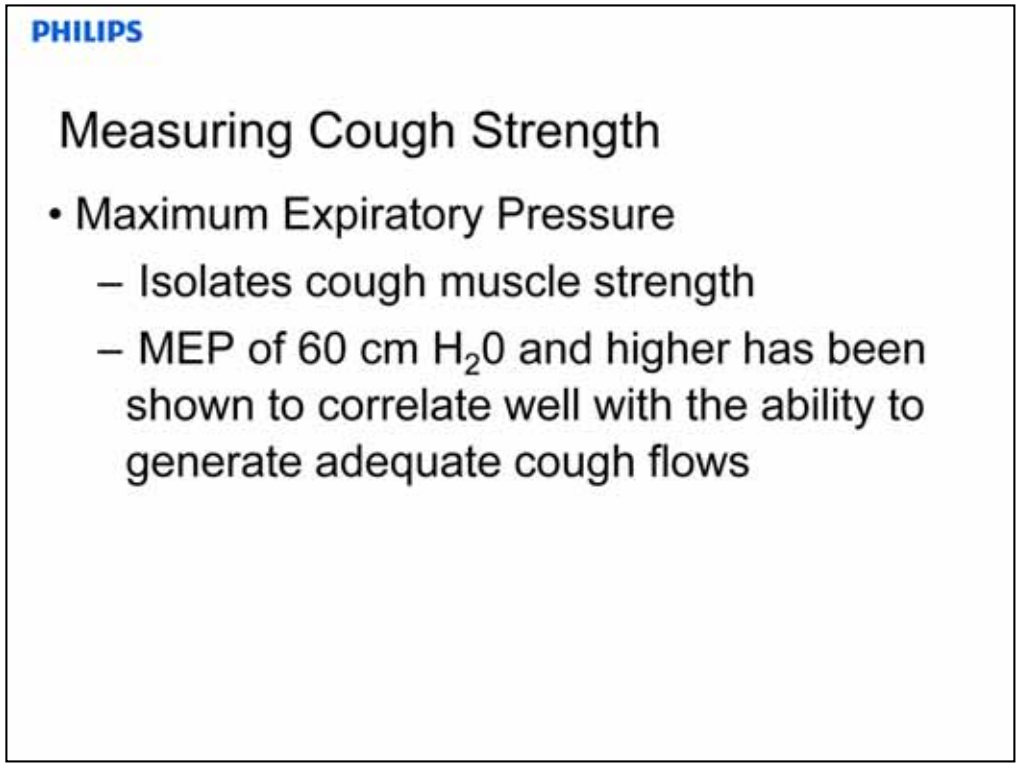
Measuring Cough Strength

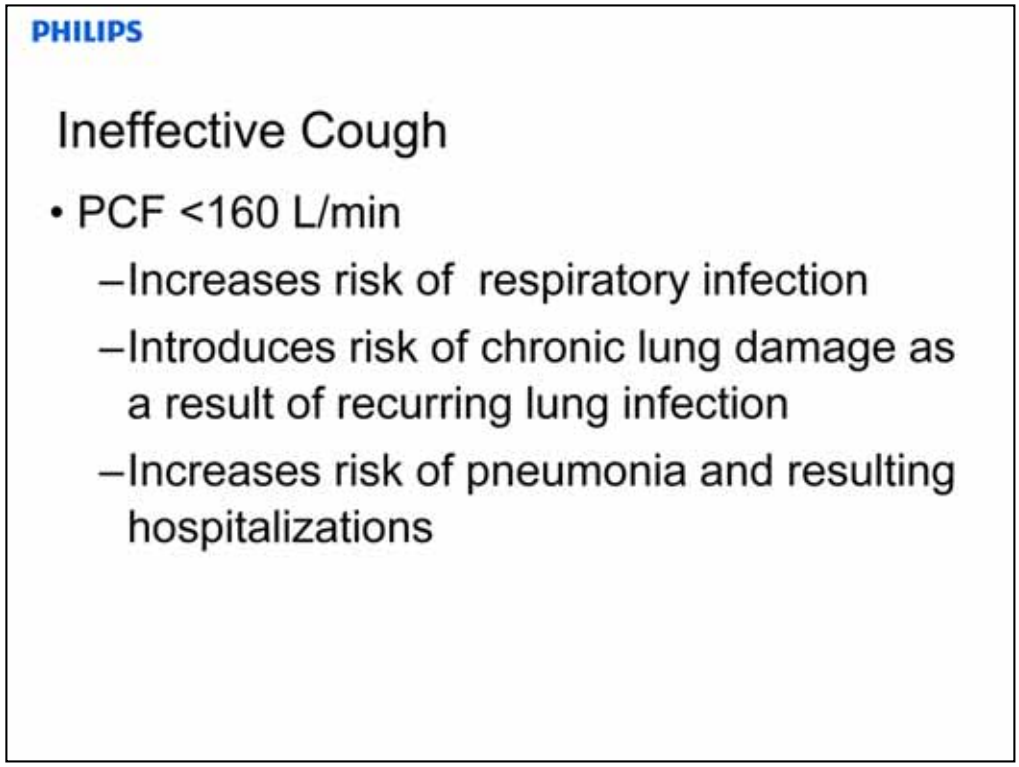
- Peak Expiratory Cough Flow
  - Measures global cough strength
  - Simple testing format
    - Peak flow meter and mask
    - Measure Peak Cough Flow (PCF)
    - Normal: 6-12 L/s or 360–720 L/m

Peak Cough Flow is used to measure the effectiveness of the cough because it captures the strength and ability of all the muscle groups involved.

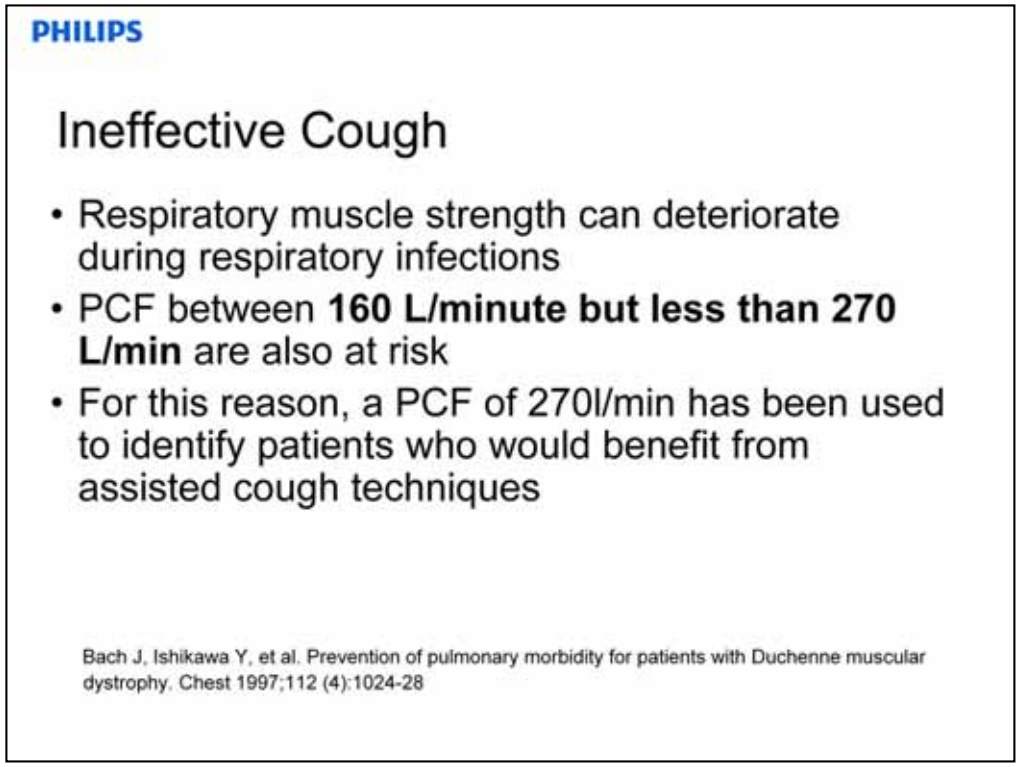
Peak cough flow can be measured very practically by attaching a naso/oral mask to an inexpensive peak flow meter and having the patient cough into the meter rather than just blowing. PCF can also be measured by a pneumotachometer that might be used for simple spirometry.



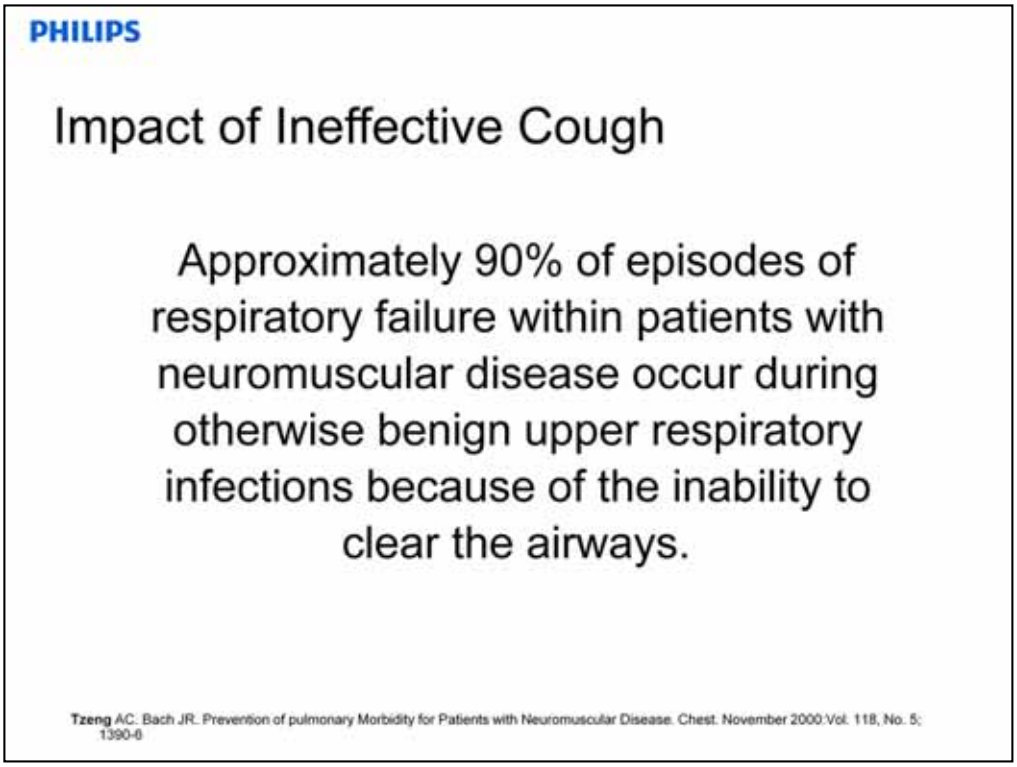
Another trending tool that can be used to monitor the strength of a cough is Maximum Expiratory Pressure. This maneuver obviously requires the ability to completely seal a mask or mouth piece but it does correlate well with the ability to clear secretions. Maximum expiratory pressures of 60 cm H2O or above have been shown to correlate well with the ability to generate adequate cough flows.



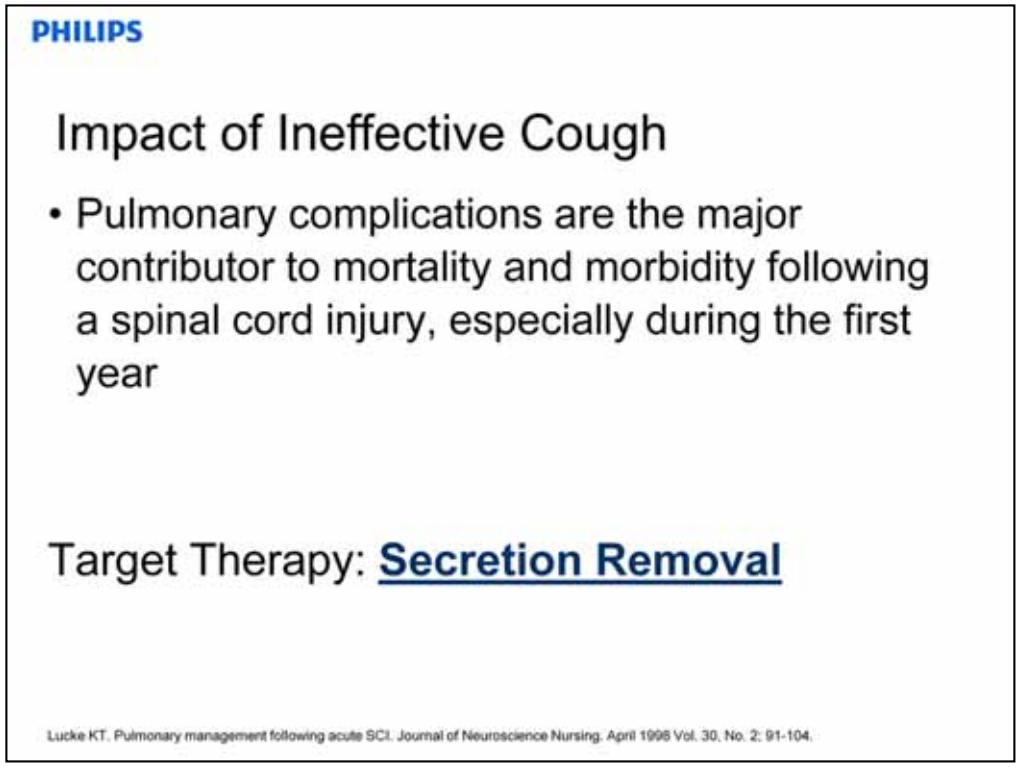
A patient needs to be able to generate a minimum peak cough flow of 160 l/min for the cough to be effective. An ineffective cough leads to an increased risk of a respiratory infection. With recurring infections, the result is lung tissue damage. And, an ineffective cough can result in pneumonia requiring hospitalization.



It is important to note that persons with a neuromuscular deficit can weaken further during respiratory infections and those with peak cough flows greater than 160l/min but less than 270l/min may still be at risk as fatigue and further weakness sets in along with a respiratory infection. For this reason, the target pcf most often used to identify those who can benefit from assisted cough is a minimum of 270l/min.

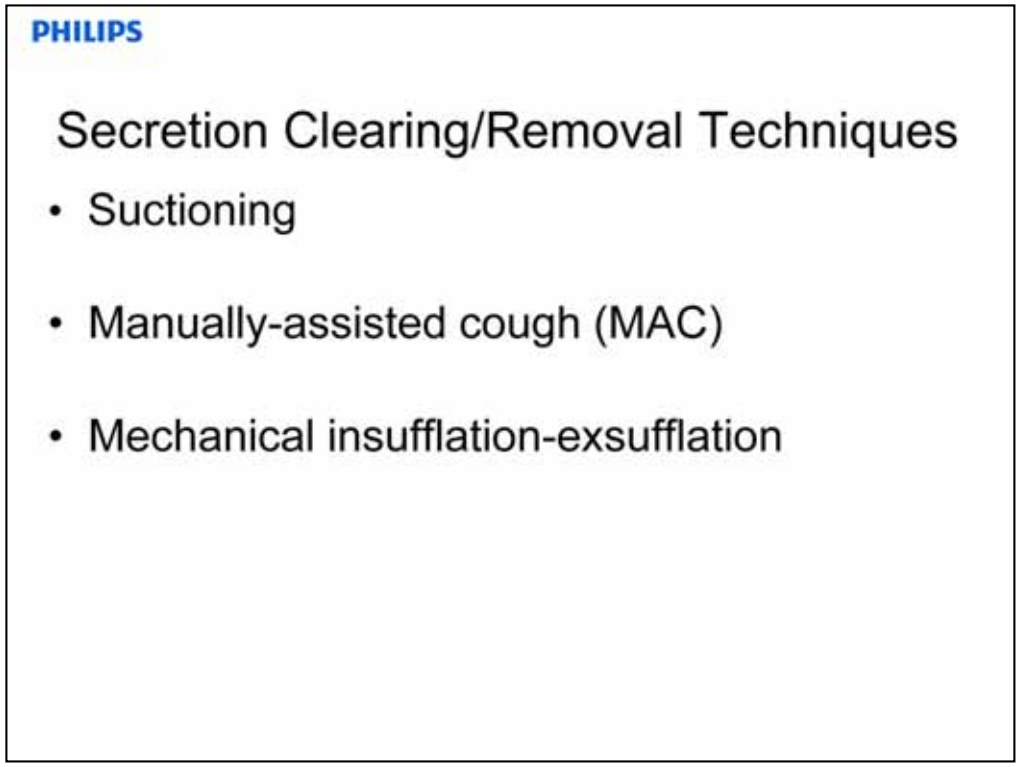


The impact of not being able to cough effectively has a significant effect on those with neuromuscular disease or spinal cord injuries. This Chest paper documented that about 90% of respiratory failure is related to upper respiratory infections that normally would be controlled by an effective cough.



For patients with spinal cord injury, pulmonary complications are the major contributor to mortality during the first year.

Target therapy for patients that have ineffective cough is secretion removal



Secretion clearance techniques include suctioning, manually-assisted cough (MAC), and mechanical insufflation-exsufflation.

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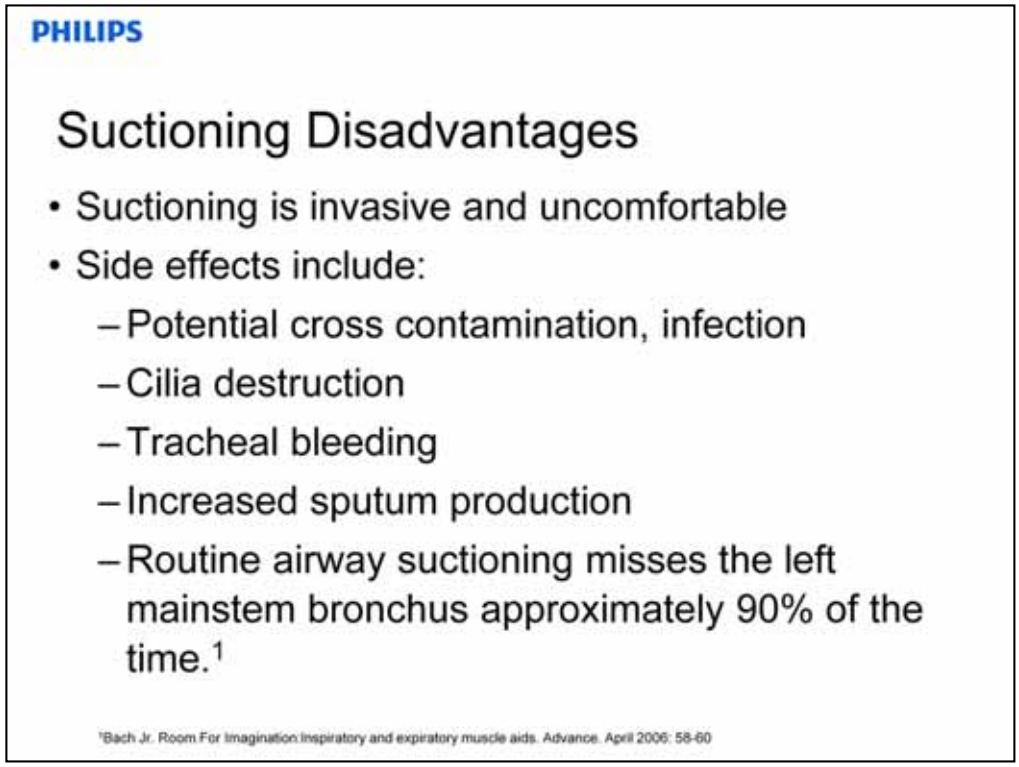
Airway Suctioning

- Has long been the standard for removal of airway secretions
- Effectively removes secretions from the upper tracheo-bronchial tree
- Easy access with artificial airways

Invasive suctioning has been the long time standard for removing secretions that cannot be coughed out. Suctioning is effective in removing secretions from the upper tracheo-bronchial tree. Tracheotomies and endotracheal tubes allow for quick and easy access.



However, suctioning is not without its disadvantages. We all know how invasive and uncomfortable suctioning can be, but there is also potential for cross contamination related to technique, tracheal and bronchial wall cilia destruction, tracheal bleeding and even an increase in sputum production in reaction to the invasiveness of the procedure. In addition, the left mainstem bronchus is missed about 90% of the time with a standard suction catheter.

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Manually Assisted Cough

- A noninvasive method of applying pressure to the abdomen, pleural space, and airway to increase peak cough flow (PCF)
- Safe and easy to teach
- Widely used during rehabilitation

Another secretion clearing technique is the manually assisted cough (MAC). MAC is safe and easy to learn and to teach. It consists of coordinating either abdominal or chest thrusts with the cooperative patient's cough effort to increase peak cough flow.

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Manually Assisted Cough

- Most important part of MAC is air stacking or maximal insufflation to deep lung volume prior to the MAC
- Methods of air stacking include using:
  - Manual Resuscitator
  - Volume Ventilator
  - Glosso-pharyngeal breathing (Frog brea

Air stacking prior to an MAC maneuver is important in order to maximize the increase in peak cough flow. There are several methods to achieve air stacking. Those include using a manual resuscitator, volume ventilator or using a technique called glosso-pharyngeal breathing. Some people refer to it as frog breathing. This technique involves the use of the glottis to add to an inspiratory effort by projecting (gulping) boluses of air into the lungs. The glottis closes with each gulp. One “breath” is about 6-9 gulps.

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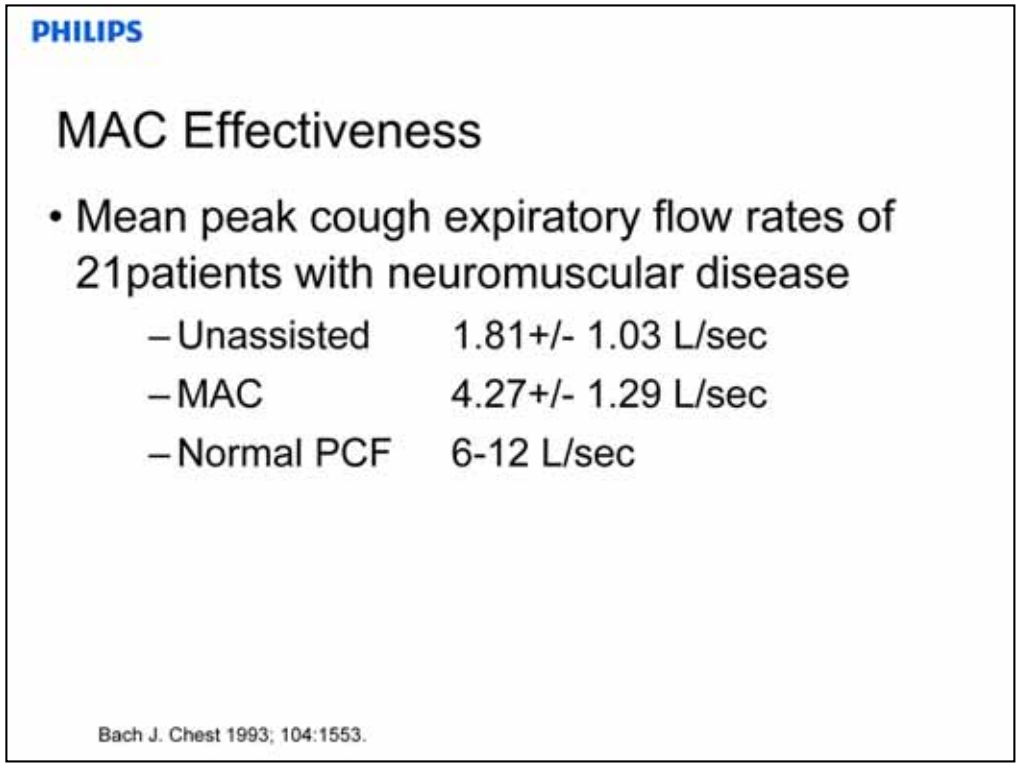
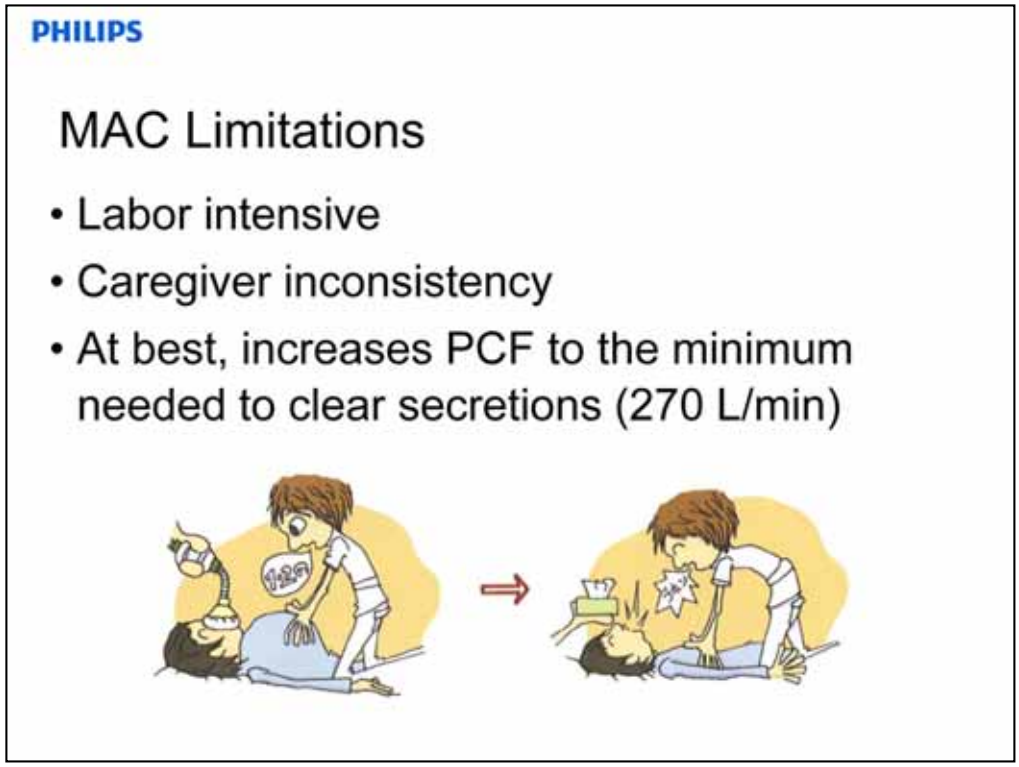
Manually Assisted Cough

Air Stacking

This slide simply shows methods used to achieve maximal insufflation, usually prior to a spontaneous cough. Other means include a volume ventilator, frog breathing and Mechanical Insufflation.



This study by Dr. John Bach illustrates the significant increase in peak cough flow with a manually assisted cough.



The limitations of MAC are that it can be labor intensive, inconsistency between caregivers, and MAC alone increases PCF only to the minimum requirement to clear secretions. It is also important to note that this procedure, MAC, is not widely taught to healthcare providers.

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Mechanical Insufflation-Exsufflation (MI-E)

- Assists patients to clear retained secretions noninvasively
- Applies a positive pressure to the airway (insufflation) followed by a rapid shift to a negative pressure (exsufflation) simulating a cough
- May be applied by mask or mouthpiece or invasively via endotracheal or tracheostomy tube

The next technique that we will discuss is clearing of secretions using Mechanical Insufflation- Exsufflation or MI-E. This not a new technique, in fact it has been used since the 1950's for Polio patients. It has been known through the years as the IN-Exsufflator but the modern version is called the CoughAssist. This therapy works nonivasively to removed retained secretions. A gradual hyperinflation is provided with positive pressure followed by a rapid shift to a negative pressure which simulates a cough. This therapy can be administered by mask, mouthpiece or invasively through a tracheostomy tube.

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Indications for Use

Any patient unable to cough or clear secretions effectively due to reduced peak cough expiratory flow < 270 L/min

Contraindications

- History of bullous emphysema
- Known susceptibility to pneumothorax or pneumo-mediastinum
- Recent barotrauma

Indications for MI-E include any patient having difficulty clearing secretions and unable to generate a peak cough flow of 270 l/m.

Contraindications are similar to other positive pressure devices and include history of bullous emphysema, pneumothoracies, and recent barotrauma.

I would delete the green……

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Benefits of Insufflation

- Neuromuscular disease - reduced VC and V_t and an inability to sigh that result in developing atelectasis and pneumonia[1]
- Provides normal hyperinflation - has been shown to combat loss of chest wall compliance and microatelectasis[2]

[1]Estenne M. et al. Lung volume restriction in patients with chronic respiratory muscle weakness: the role of microatelectasis. Thorax 1993:48(7):698-701
[2]Estenne M. et al. Chest wall stiffness in patients with chronic respiratory muscle weakness. Am Rev Respir Dis 1983;128(6):1002-1007

Insufflation helps to combat atelectasis and pneumonia by delivering sigh-like breaths as well as providing a range of motion type exercise for the improvement of external chest wall compliance.

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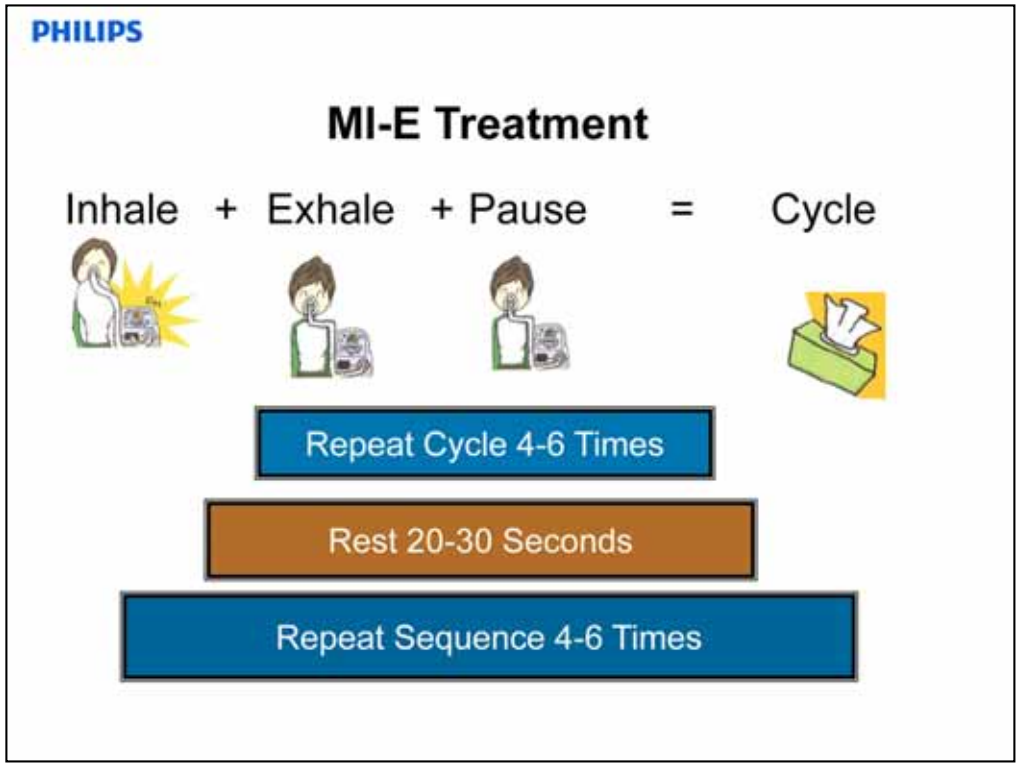
Benefits of Exsufflation

- Flow simulates a natural expiratory cough flow (6-10 L/sec)
- More effective than invasive suctioning since suctioning has been shown to miss the left mainstem bronchus 90% of the time[1]
- Potentially eliminates the need for invasive suctioning

[1]Bach Jr. Room For Imagination:Inspiratory and expiratory muscle aids. Advance. April 2006: 58-60

The benefits of Exsufflation include generating 6-10 L/sec peak cough flow which is the highest of the assisted cough techniques. The need for invasive suctioning can often be eliminated.



A cough cycle consists of inhalation, exhalation and pause

4 to 6 cough cycles given in rapid succession.

The patient is then allowed to rest for 20 – 30 seconds.

A full treatment consists of repeating the above sequence 4 – 6 times.

The patient may not need 4 – 6 sequences to clear their secretions. If the patient has more secretions to clear, the patient must be rested for 5 minutes before resuming another treatment.

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Typical MI-E settings

- Pressures (positive and negative)
  - Start low, 10 to 15 cm H_20
  - Get patient acclimated to device
  - Increase pressures as tolerated, **35 to 45 cm** H_20 ideally[1]
- Times (Inhale, Exhale and Pause)
  - Small Children: 1 to 2 sec
  - Adults: 2 to 3 sec

[1]Gomez-Marino E et al.Mechanical insufflation-exsufflation. Pressure,volume, and flow relationship adequacy of the manufacturer's guidelines. Am J Phys Rehabil 2002;81(8):579-583.

As far as machine settings, there are mainly 2 – set pressures and times. When first starting someone on the CA, it is recommended to start with low pressures of 10-15 cm H_20 allowing for an acclimation period.

Ideally we want to get to higher pressures

Higher pressures = higher peak cough flow = better secretion removal

Times listed here are good starting points and can be adjusted for patient comfort and treatment efficacy.

A Pause can be set between each cough cycle for patient comfort and to aid with patient/machine coordination.

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Settings

- **The goal** of inspiratory pressure is to give the patient a good hyper-expansion
- **The goal** of expiratory pressure is to replace a good expiratory cough flow
- Pressures and times vary with each patient

It is important to remember the goals of using MI-E. Insufflation should be set to deliver a breath approaching maximal inspiratory capacity, this can be determined by physical assessment or auscultation. The exsufflation should be set high enough to provide PCF simulating a normal cough flow.

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Settings

- Important to work with patient to find settings which are both comfortable and effective
- Studies have shown that therapeutic PCF may not be reached with MI-E Expiratory Pressures less than -40 cm H_20

Each patient's pressures may be a little different based upon their lung compliance and resistance. Therefore we need to work with each patient to find comfortable settings that meet the clinical goals.

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Clinical Benefits

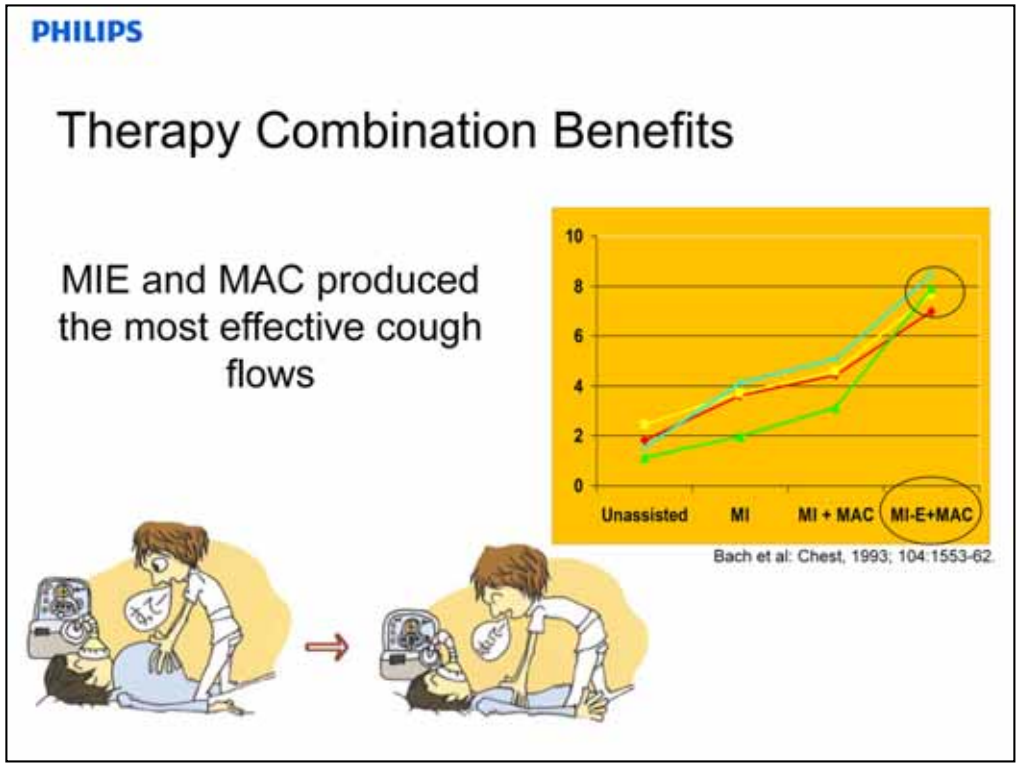
- Mean peak cough expiratory flow rates of 21 patients with NMD studied
  - Unassisted 1.81 ± 1.03 L/sec
  - Assisted cough 4.27 ± 1.29 L/sec
  - MI-E and MAC 7.47 ± 1.02 L/sec

(Normal PCF is 6-12 L/sec)

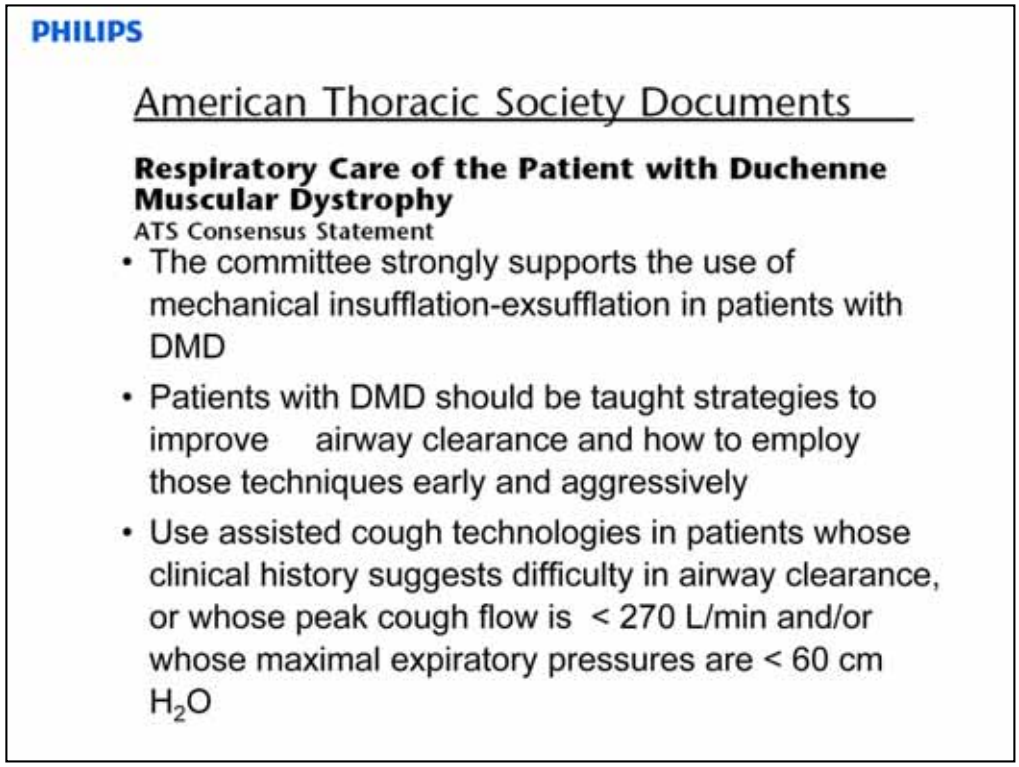
- Conclusion: In-exsufflator cough machine improved peak cough expiratory flow rates

Bach J. Chest 1993; 104:1553.

This study, published in CHEST, shows the PCF improving with the use of an assisted cough, and significantly increasing when using both MI-E and MAC together.

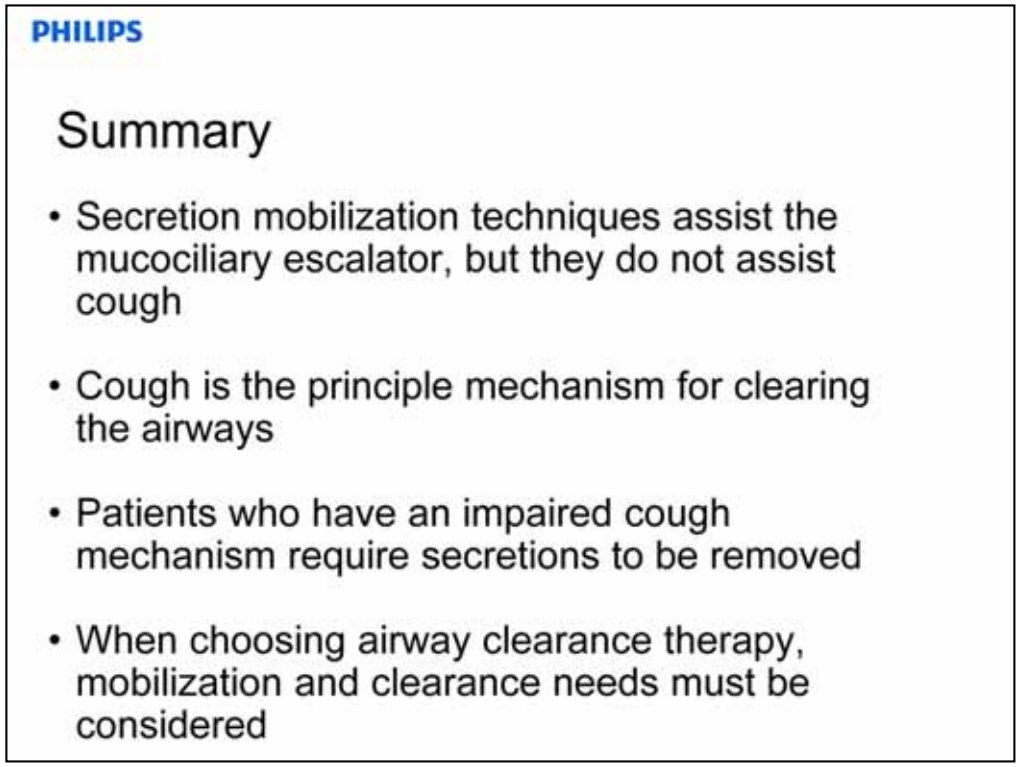


This slide shows the results of the study on a graph. As you can see, the use of mechanical insufflation-exsufflation in combination with a manual assisted cough technique produces the highest peak expiratory cough flows in all 4 diagnosis groups.



The American Thoracic Society has issued this consensus statement encouraging the use of the MI-E with those diagnosed with DMD. It is important that patients are taught strategies to improve airway clearance early and aggressively. ATS recommends that assisted cough technologies be instituted when

1. Patient has a clinical history that suggests difficulty clearing their airways
2. Peak flow is <270 L/min
3. Maximal expiratory pressure is less than 60 cm H_2O



In summary, secretion clearance techniques fit into two categories; secretion mobilization and secretion clearance. Mobilization techniques may loosen secretions but they do not assist with the cough to remove secretions. The strength of the cough should be evaluated and considered when choosing which secretion clearance technique is most appropriate for your patient's care.

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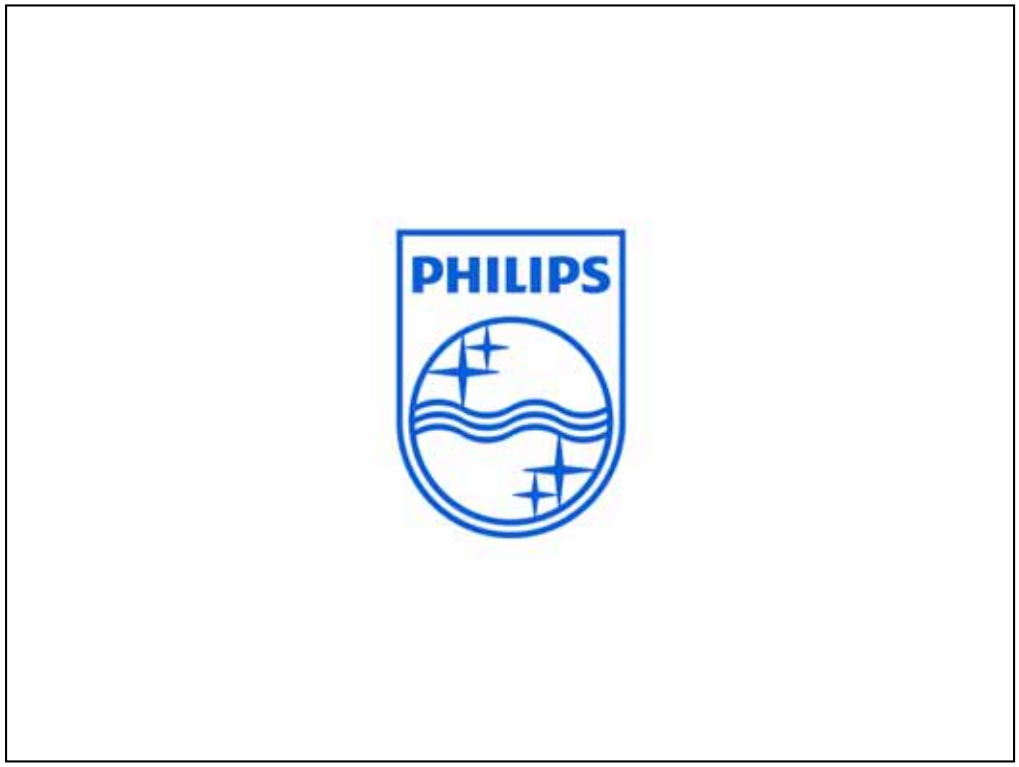
Thank You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