Nonpharmacologic Airway Clearance Therapies: ACCP Evidence-Based Clinical Practice Guidelines

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ACCP Evidence-Based Clinical Practice Guidelines

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Background: **Airway clearance may be impaired in disorders associated with abnormal cough mechanics, altered mucus rheology, altered mucociliary clearance, or structural airway defects. A variety of interventions are used to enhance airway clearance with the goal of improving lung mechanics and gas exchange, and preventing atelectasis and infection.**
Method: **A formal systematic review of nonpharmacologic protussive therapies was performed and constitutes the basis for this section of the guideline. In addition, the articles reviewed were found using the same methodology but were not limited to those that focused only on cough as a symptom. The MEDLINE database was searched for this review and consisted of studies published in the English language between 1960 and April 2004. The search terms used were "chest physiotherapy," "forced expiratory technique," "positive expiratory pressure," "high frequency chest compression," "insufflation," and "exsufflation."**
Results: **In general, studies of nonpharmacologic methods of improving cough clearance are limited by methodological constraints, and most were conducted only in patients with cystic fibrosis. Chest physiotherapy, including postural drainage, chest wall percussion and vibration, and a forced expiration technique (called *huffing*), increase airway clearance as assessed by sputum characteristics (*ie*, volume, weight, and viscosity) and clearance of the radioaerosol from the lung, but the long-term efficacy of these techniques compared with unassisted cough alone is unknown. Other devices that allow patients to achieve the same benefits derived from chest physiotherapy without the assistance of a caregiver appear to be as effective as chest physiotherapy in increasing sputum production.**
Conclusions: **Some nonpharmacologic therapies are effective in increasing sputum production, but their long-term efficacy in improving outcomes compared with unassisted cough alone is unknown.** ***(CHEST 2006; 129:250S–259S)***

Key words: airway clearance; chest physiotherapy; cough; exsufflation; forced expiratory technique; huffing; insufflation; mucociliary clearance; oscillation; percussion; protussive; positive expiratory pressure; vibration

Abbreviations: CF = cystic fibrosis; FET = forced expiratory technique; PEP = positive expiratory pressure

Airway clearance may be impaired in patients with disorders that are associated with abnormal cough mechanics (*eg*, muscle weakness), altered mucus rheology (*eg*, cystic fibrosis [CF]), altered mucociliary clearance (*eg*, primary ciliary dyskinesia), or structural defects (*eg*, bronchiectasis.) A variety of interventions are used to enhance airway clearance with the goal of improving lung mechanics and gas exchange, and preventing atelectasis and infection. Some of these interventions require the presence of a caregiver (assisted maneuvers), while others can be performed without assistance. Studies of these maneuvers compare the use of an intervention with no intervention, compare one intervention with another, or compare combinations of modalities. In general, these studies have many methodological limitations. Most assess only short-term effects on airway clearance by measuring qualities of

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sputum (*ie*, volume, weight, and viscosity) or rates of clearance of radiolabeled aerosol from the lung. While some modalities yield short-term improvements in these markers, very few measure long-term and clinically important end points like health-related quality of life or rates of exacerbations, hospitalizations, and mortality. In addition, most studies of nonpharmacologic methods to improve both cough effectiveness and airway clearance were conducted exclusively in patients with CF.

Each cough clears material from the central airways, and propels some secretions from peripheral to central airways. Diseases that alter mucus rheology or impair mucociliary clearance can impair cough effectiveness by impeding the delivery of secretions to the central airways, where they are removed by cough. For the purposes of this review, nonpharmacologic measures aimed at improving mucociliary clearance will be considered to improve cough effectiveness by their contribution to airway clearance. To this end, some articles were included in this section-specific review that were not included in the formal systematic review by the Duke University Center for Clinical Health Policy Research, which focused on the narrow definition of cough as a symptom. These articles were found using the same methodology as in the systematic review search, but were not limited to those studies that deal specifically with cough. The MEDLINE database was searched for this review and consisted of studies published in the English language between 1960 and April 2004. The search terms used were "chest physiotherapy," "forced expiratory technique" (FET), "positive expiratory pressure" (PEP), "high frequency chest compression," "insufflation," and "exsufflation." Pharmacologic treatments to improve airway clearance are discussed in the section "Cough Suppressant and Pharmacologic Protussive Therapy" in this guideline.

Assisted Techniques

Chest Physiotherapy (Percussion, Postural Drainage, and Vibration)

Physical therapy techniques have been employed alone and in combination to facilitate airways clearance and to render cough more effective. The systematic review of randomized controlled trials assessing the effects of these techniques on cough are summarized in Table 1; they include postural drainage[1–7] as well as percussion, vibration,[8–11] and shaking of the chest wall. Taken together, these maneuvers can be grouped under the term *chest physiotherapy* and are long established as the standard of care in patients with CF, and in selected patients with other pulmonary conditions, as a way to enhance the removal of tracheobronchial secretions.[2,12–20] However, chest physiotherapy is time-consuming, may require the assistance of a therapist or other caregiver, and may be uncomfortable or unpleasant, and there have been few well-designed randomized trials to show its efficacy. Most studies of chest physiotherapy are limited by short duration, the use of different measurements of mucus clearance (including the clearance of radioaerosol technetium and the measurement of expectorated sputum weight or volume), and the lack of assessment of long-term outcomes like pulmonary function, rates of hospitalization, morbidity, and mortality.

A systematic literature review that was designed to evaluate whether standard chest physiotherapy was more effective in clearing mucus compared to "no treatment" or "spontaneous coughing" in patients with CF identified 120 studies.[21] Only 6 studies were included in the final analysis because 101 studies lacked an appropriate control group, and the others were excluded because they were not clinical trials, included other diagnoses, did not evaluate therapy, or included no data. The trials that were finally analyzed were designed as short-term crossover studies.[2,5,22–25] They suggest that airway clearance regimens in general have beneficial effects in patients with regard to improving mucus transport, but outcome variables differed among them; three studies[2,22,25] reported the amount of expectorated secretions, two studies[25,26] measured total lung capacity and functional residual capacity, and three studies[2,5,23] measured radioactive tracer clearance. The efficacy of each component of chest physiotherapy cannot be evaluated from the current literature, and no study investigated health-related quality-of-life measures, compliance with therapy, the number of exacerbations or hospital days per year, the costs or harm associated with intervention, or mortality rates. Despite the lack of proven efficacy of chest physiotherapy in these outcomes, the ethics of performing a long-term randomized trial that withholds this intervention from patients with CF is problematic, as this treatment is considered to be the standard of care and has established short-term benefit in increasing expectorated sputum volume and enhancing mucus clearance as assessed by radioactive tracer techniques.

The efficacy of chest physiotherapy in disorders other than CF (*eg*, COPD and bronchiectasis) has been less well-studied. An evidence-based review[27] of five studies on the role of chest physiotherapy in patients with bronchiectasis due to a variety of disorders (including a few cases of CF) suggested that, as in CF, it increases the amount of expectorated sputum, has no effect on FEV_1, and is beneficial only in patients who typically produce >20 to 30 mL of mucus daily.

Table 1—*Protussive Maneuvers

Treatment	Reference	Subjects, No./Dx	Age,† yr	Dosing	Results	p Value
CPT	12	8/CB	55–70	bid for 3 d	No significant improvement in FEV_1 between control and CPT groups	NS
CPT	13	10/COPD, B	63 ± 13	CPT 20 min/d for 2 d	CPT produced more sputum than control subjects	< 0.01
CPT	14	6/COPD	60 ± 16	CPT 20 min	CPT produced more sputum than control subjects	< 0.05
CPT	15	9/CF	12 ± 4	CPT once daily for 2 d	CPT cleared more radiotracer than cough alone	< 0.001
CPT	16	10/CF	11	CPT bid for 3 wk	No significant change in FEV_1 with CPT, but FEV_1 declined without CPT	NS
CPT	2	6/CF	23	40 min of CPT	CPT cleared more radiotracer than control or PD alone	< 0.05
CPT	17	69/CB, CHF	54–64	Once daily for 10 d	No difference in sputum weight compared to baseline	NS
CPT + exercise	18	8/CF	18–27	CPT 25–40 min/d for 2 d	CPT + exercise produced more sputum than CPT alone	0.023
AD	55	17/CF	20 ± 10	AD bid for 4 wk	Cough clearance and FEV_1 were not different than with a flutter device	NS
PD	1	18/CF	22	15 min of PD	Sputum weight was greater with flutter than PD or DC alone	< 0.001
PD	2	6/CF	23	40 min of PD	PD did not clear radiotracer as effectively as CPT	< 0.05
PD	3	28/CF	14–34	PD 30 min tid for 2 d	Sputum wet weight was greater with PD than with HFCWO	0.035
PD	4	17/CF	6–24	PD for 20 min	Sputum volume greater compared to baseline	< 0.001
P	8	14/CF	7–21	32 min	No difference in sputum weight or FEV_1 between mechanical and manual percussion	NS
P	9	51/CF	6–18	30 min tid	No difference in FEV_1 between mechanical and manual percussion	NS
PD + P	10	13/B	31–68	10 min	No differences in FEV_1 or sputum weight when P added to PD	NS
PD + FET	5	10/CF	15–26	20 min of PD with FET	PD + FET cleared radiotracer better than control group at 30 min but not at 3 h	< 0.01
PD + FET	6	9/CF	12–36	20 min of PD and FET	No difference in radiotracer clearance between PD + FET and PEP or physical exercise	NS
PD + FET	33	10/CF, B	41 ± 16	30 min of PD and FET	Greater clearance of radiotracer with FET + PD than during a control period	< 0.01
DC	37	8/CB	62 ± 4	1 cough/min for 5 min	DC cleared radiotracer better than control	< 0.01
DC	33	10/CF, B	41 ± 16	30 min of directed cough	No difference in radiotracer between DC and a control period	NS
or FET				or FET for 30 min	Greater clearance of radiotracer with FET when compared to a control period	< 0.01
DC + exercise	37	8/CB	62 ± 4	1 cough/min for 5 min and exercise for 40 min	Greater clearance of radiotracer with cough + exercise than rest	< 0.03
FET + PD + DC	39	8/CF, B	15–27	30 min	No difference in radiotracer clearance between FET + PD + DC and PD + DC	NS
FET + PEP	40	22/CF	7–17	bid for 2 wk	No difference in FEV_1 between FET + PEP and PEP + flutter	NS
FET + PD + P	11	10/B	22–58	Variable	Addition of percussion to FET and PD improved clearance (sputum weight)	< 0.05

*Dx = diagnosis; CPT = chest physiotherapy; AD = autogenic drainage; PD = postural drainage; P = percussion; B = bronchiectasis; CB = chronic bronchitis; CHF = congestive heart failure; HFCWO = high-frequency chest wall oscillation; NS = not significant; DC = directed cough.

†Values are given as range or mean ± SD.

Nevertheless, chest physiotherapy is still considered to be the standard of care in patients with CF. There is still insufficient evidence to recommend this therapy for patients with other disorders.

Recommendation

1. In patients with CF, chest physiotherapy is recommended as an effective technique to increase mucus clearance, but the effects of each treatment are relatively modest and the long-term benefits unproven. Level of evidence, fair; benefit, small; grade of recommendation, C

Manually Assisted Cough

Paradoxical outward motion of the abdomen during cough may occur in individuals with neuromuscular weakness or structural defects of the abdominal wall, and this paradoxical motion contributes to cough inefficiency. Reducing this paradox either by manually compressing the lower thorax and abdomen or by binding the abdomen should theoretically improve cough efficiency.[28] The manually assisted cough maneuver consists of applying pressure with both hands to the upper abdomen following an inspiratory effort and glottic closure. This maneuver was shown in an uncontrolled study to improve peak cough expiratory flow between 14% and 100%.[29] A disadvantage of the assisted cough maneuver is that it requires the presence of a caregiver, and that it is often not well-tolerated and ineffective in patients with stiff chest walls (*eg*, patients with severe scoliosis), with osteoporosis, who have undergone abdominal surgery, or with intraabdominal catheters. An evidence-based review of respiratory complica-

tions in cervical spinal cord-injured individuals[30] supports the notion that cough can be made more effective in these individuals by using manual assistance or positive-pressure insufflation devices. However, in patients with COPD, manually assisted cough alone or in combination with mechanical insufflation was detrimental, decreasing peak expiratory flow rate by 144 L/min (95% confidence interval, 25 to 259 L/min) and 135 L/min (95% confidence interval, 30 to 312 L/min), respectively.[31]

Recommendations

2. In patients with expiratory muscle weakness, manually assisted cough should be considered to reduce the incidence of respiratory complications. Level of evidence, low; benefit, small; grade of recommendation, C

3. In persons with airflow obstruction caused by disorders like COPD, manually assisted cough may be detrimental and should not be used. Level of evidence, low; benefit, negative; grade of recommendation, D

Unassisted Techniques

The questionable efficacy of chest physiotherapy, together with the undesirable qualities of needing an assistant, inconvenience, discomfort, and the likelihood that long-term compliance is less than optimal led to the study of techniques that were designed to either enhance the results of standard chest physiotherapy or produce comparable results with less rigorous demands on patient time and effort.

FET

Patients with chronic airway disease of any etiology (*ie*, COPD, CF, and bronchiectasis) may have abnormally compliant central intrathoracic airways that collapse during cough, thereby impairing the clearance of secretions. To minimize this phenomenon, the forced expiratory technique (also called *huffing*) was introduced as an alternative to cough.[32] This maneuver consists of one or two forced expirations without closure of the glottis starting from mid-lung to low lung volume, followed by relaxed breathing.[33] Because the intrapulmonary pressures during FET are lower than with those with cough, the FET may lead to less airway compression and better sputum clearance.[34–36] Using radioaerosol measurement of mucus clearance in patients with COPD, huffing was as effective as directed cough in moving secretions proximally from all regions of the lung,[33,37,38] but huffing with postural drainage was not more effective than postural drainage with cough in CF or chronic bronchitis.[39] These findings imply that patients can use huffing to enhance clearance without excessive effort. In patients with CF, huffing with postural drainage or PEP improved sputum clearance when compared to no treatment,[5] but had little effect on FEV_1.[40]

Recommendation

4. In patients with COPD and CF, huffing should be taught as an adjunct to other methods of sputum clearance. Level of evidence, low; benefit, small; grade of recommendation, C

Autogenic Drainage

Autogenic drainage is a technique that utilizes controlled expiratory airflow during tidal breathing to mobilize secretions in the peripheral airways and move them centrally. This technique has been primarily tested in patients with CF. Autogenic drainage consists of the following three phases: (1) "unsticking" the mucus in the smaller airways by breathing at low lung volumes (*ie*, tidal breaths are performed below functional residual capacity); (2) "Collecting" the mucus from the intermediate-sized airways by breathing at low to middle lung volumes; and (3) "evacuating" the mucus from the central airways by breathing at middle to high lung volumes. The individual then coughs or huffs to expectorate the mucus from the large airways. Autogenic drainage has been evaluated as an alternative to chest physiotherapy in patients with CF. The advantage of autogenic drainage over postural drainage is that it can be performed in the seated position without the assistance of a caregiver. In a randomized crossover trial of radioaerosol clearance measurements in 18 patients with CF, autogenic drainage cleared mucus from the lungs faster than postural drainage, but there were no significant differences in spirometry findings.[41]

Recommendation

5. In patients with CF, autogenic drainage should be taught as an adjunct to postural drainage as a method to clear sputum because it has the advantage of being performed without assistance and in one position. Level of evidence, low; benefit, small; grade of recommendation, C

Respiratory Muscle Strength Training

Individuals with neuromuscular disease may have weakened inspiratory and/or expiratory muscles. Be-

cause the weakness of both muscle groups impairs cough, strengthening them may improve cough effectiveness. In general, the respiratory muscles of healthy subjects can be trained for strength or endurance.[42–44] Strengthening the inspiratory muscles may enhance cough effectiveness by increasing the volume of air inhaled during the inspiratory phase of cough, whereas strengthening the expiratory muscles may improve cough effectiveness by increasing intrathoracic pressure during the expiratory phase. Inspiratory muscle training in persons with muscular dystrophy can increase vital capacity, but this effect is more pronounced in individuals with less severe disease.[45] Studies evaluating expiratory muscle training in individuals with neuromuscular disease are limited. In quadriplegic subjects, expiratory muscle training leads to a 46% increase in expiratory reserve volume.[46] This increase in expiratory reserve volume was accomplished by isometric training of the clavicular portion of the pectoralis major over a 6-week period. This protocol may improve cough effectiveness by enabling patients with neuromuscular weakness to generate higher intrathoracic pressures, but it has not been tested in clinical trials.

Recommendation

6. In patients with neuromuscular weakness and impaired cough, expiratory muscle training is recommended to improve peak expiratory pressure, which may have a beneficial effect on cough. Level of evidence, expert opinion; benefit, small; grade of recommendation, E/C

Devices

Many devices have been investigated in an attempt to augment the beneficial effects of conventional chest physiotherapy or to allow the patient to achieve these benefits without assistance. Most of these studies were performed in patients with CF, and most compared the effects of treatment with the device with conventional physiotherapy, or the effects of the device in addition to physiotherapy. These studies have not directly addressed the efficacy of self-administered therapy, as study subjects had "self-administered" treatments supervised by therapists, which may lead to better performance than when patients are unsupervised. Table 2 summarizes the randomized controlled trials on the use of these devices to improve cough clearance.

PEP

The administration of PEP from 5 to 20 cm H_2O delivered by facemask is believed to improve mucus clearance by either increasing gas pressure behind secretions through collateral ventilation[47] or by preventing airway collapse during expiration.[48] Most studies[5,6,26,40,49–52] of PEP were performed in patients with CF, but some[39,53] have included patients with chronic bronchitis. A Cochrane review[54] of studies of PEP compared with standard chest physiotherapy in patients with CF included 20 studies that met the inclusion criteria. Taken together, they showed no differences between physiotherapy and PEP in short-term effects on airway clearance and FEV_1, and conflicting results on the long-term effects on FEV_1. However, in studies with an intervention period of at least 1 month, patients tended to prefer PEP.

Recommendation

7. In patients with CF, PEP is recommended over conventional chest physiotherapy because it is approximately as effective as chest physiotherapy, and is inexpensive, safe, and can be self-administered. Level of evidence, fair; benefit, intermediate; grade of recommendation, B

In the only outcome study to evaluate the impact of PEP therapy in patients with chronic bronchitis, Christensen and colleagues[53] investigated whether PEP therapy was a useful adjunct to "self-administered diaphragmatic breathing followed by forced expirations and cough until expectoration succeeded" in a group of patients with chronic bronchitis. After 5 to 12 months of follow-up, the PEP group reported less cough, less mucus production, fewer exacerbations, and less use of antibiotic and mucolytic agents. The PEP group also had a trend toward improved FEV_1 compared with the control group. However, a lack of blinding of subjects and investigators brings the validity of the conclusions into question. More studies of this intervention in patients with chronic bronchitis are needed before it can be recommended.

Oscillatory Devices (Flutter, Intrapulmonary Percussive Ventilation, High-Frequency Chest Wall Oscillation)

The effects of oscillating gas in the airway with the aim of enhancing mucus clearance have been investigated in several clinical trials. High-frequency oscillations can be applied either through the mouth or chest wall causing the airways to vibrate, thereby mobilizing pulmonary secretions. These devices can be used with the patient seated or supine. The "flutter" device (Varioraw SARL; Scandipharm Inc; Birmingham, AL) is a plastic pipe with a mouthpiece at one end and a perforated cover at the other end. Within the device, a high-density stainless steel ball

Table 2—*Protussive Devices

Treatment	Reference	Subjects, No./Dx	Age,† yr	Dosing	Results	p Value
PEP	48	20/CF	5–29	bid for 10 mo	FEV_1 improved following 10 mo of PEP	< 0.01
PEP	26	8/CF	13–21	20 min	No improvement in sputum clearance compared to baseline	NS
PEP	49	19/CF	10–18	20 min bid	No change in FEV_1 compared to PD, P and DC	NS
PEP	40	22/CF	7–17	bid for 2 wk	No change in FEV_1 compared to baseline	NS
PEP	39	7/CB	48–73	20 min	No difference in regional lung clearance compared to FET or baseline	NS
PEP + FET	50	18/CF	13–37	qd for 3 d	Sputum volume was increased but no change in FEV_1 when compared to baseline	< 0.05
PEP + FET	6	9/CF	12–36	20 min	No difference in regional lung clearance compared to FET + PD	NS
PEP + FET	34	43/CB		bid for 5–12 mo	PEP + FET improved cough symptoms, mucus production and increased FEV_1 compared to FET	< 0.04
PEP + FET	5	10/CF	15–26	20 min	Increased radioaerosol clearance compared to no treatment	< 0.05
Flutter	55	14/CF	7–41	bid for 4 wk	No difference in sputum volume or FEV_1 compared to AD but sputum viscosity lower	NS < 0.01
Flutter	40	22/CF	7–17	bid for 2 wk	No difference in FEV_1 compared to PEP	NS
Flutter	1	18/CF	8–38	tid for 2 wk	Increased sputum volume compared to PD or directed cough	< 0.001
Flutter	56	14/COPD, CB, B		2 treatments	No difference in sputum volume or FEV_1 compared to PD + P	NS
Flutter	57	17/B		bid for 4 wk	No difference in sputum weight, peak flow, or Borg score compared to active cycle breathing	NS
HFCC	60	50/CF	23 ± 2	3–4 min tid for 2 wk	Increased sputum wet weight and FEV_1 compared to baseline. HFCC not different than CPT	< 0.05 NS
HFCC	61	5/CF		30 sessions	Increased sputum volume compared to baseline and CPT	< 0.001
HFCC	62	29/CF	7–47	30 min tid for 4 d	Increased sputum wet and dry weight compared to CPT	< 0.01
HFCC	64	14/CF	14–34	20 min/h for 4 h	No difference in sputum volume or FEV_1 compared to CPT or IPV	NS
HFCC	25	16/CF	20 ± 4		No difference in sputum volume or FEV_1 compared to PD or PEP; all treatments increased sputum volume compared to control	NS < 0.05
HFCC	63	10/CF	9–16	2 sessions in one day	Less sputum production with HFCC compared to active cycle breathing	< 0.01
IPV	58	9/CF	7–40	3 treatments	No difference in sputum volume compared to CPT; no difference in FEV_1 compared to baseline	NS
IPV	3	28/CF	14–34	30 min TID for 2 days	Increased sputum volume compared to HFCWO	< 0.01

*HFCC = high-frequency chest compression. See Table 1 for other abbreviations not used in the text.
†Values are given as range or mean ± SD.

rests in a circular cone and creates a valve. Exhaling through the device creates oscillations in the airway, the frequency of which can be modulated by changing the inclination of the pipe. The few randomized clinical trials[1,40,55–57] of this device have suggested that it is somewhat effective in increasing sputum production, but there have been no studies of the long-term effects.

Another method of oscillating gas in the airway to facilitate the removal of secretions uses an "intrapulmonary percussive ventilator" (Percussionator, IPV-1; Percussionaire; Sand Point, ID). This device uses small bursts of air at 200 to 300 cycles per minute along with entrained aerosols delivered through a mouthpiece. The putative mechanisms for efficacy include bronchodilation from increased airway pressure, increased airway humidification, and cough stimulation. A pilot study[58] of the device in patients with CF suggested that it offers the patient an alternative to conventional chest physiotherapy as a means to enhance sputum production, but a 6-month study[59] of intrapulmonary percussive ventilation vs standard aerosol and chest physiotherapy in 16 patients with CF showed no differences in spirometric measures, the number of hospitalizations, the use of oral or IV antibiotics, or anthropomorphic measurements.

The method of high-frequency oscillation applied

to the chest wall has been referred to as either *high-frequency chest compression* or *high-frequency chest wall oscillation*. Studies evaluating the effects of chest wall oscillation on sputum clearance are inconclusive, either showing improved sputum production[25,60–62] or no benefit[25,60,63,64] when compared to other methods of chest physiotherapy. High-frequency chest compressions delivered through an inflatable vest linked to an air-pulse delivery system was compared with conventional physical therapy.[60] Both forms of treatment resulted in similar improvements in spirometry and sputum dry weights and hospital length of stay, although the sputum wet weight in a 1-h collection (but not a 24-h collection) was higher with chest compression ($p < 0.035$).

Recommendation

8. In patients with CF, devices designed to oscillate gas in the airway, either directly or by compressing the chest wall, can be considered as an alternative to chest physiotherapy. Level of evidence, low; benefit, conflicting; grade of recommendation, I

Mechanical Insufflation-Exsufflation

Modalities directed at increasing the volume inhaled during the inspiratory phase of cough also increase cough effectiveness. Normally, the inspiratory phase of cough optimizes the length-tension properties of the expiratory muscles and increases lung recoil pressure. The inability of patients with respiratory muscle weakness to achieve high lung volumes contributes to cough ineffectiveness. In an uncontrolled study of patients with muscle weakness, increasing the inhaled volume prior to cough by air stacking positive-pressure breaths or by glossopharyngeal breathing increased cough expiratory flows by 80%.[29] Cough efficiency can be further enhanced when the initial inspiration is followed by the application of negative pressure to the airway opening for a period of 1 to 3 s. Using this technique of mechanical insufflation-exsufflation, peak cough expiratory flows can be increased by more than four-fold.[29] In a retrospective study[65] of a cohort of patients with neuromuscular disease who had more than one episode of respiratory failure or whose assisted peak cough flows decreased to < 270 L/min, using a protocol of noninvasive intermittent positive-pressure ventilation, and manually and mechanically assisted coughing, was associated with lower hospitalization rates for respiratory complications than before the protocol was started. Similar findings were seen in a cohort of pediatric patients with neuromuscular disease.[66]

Recommendation

9. In patients with neuromuscular disease with impaired cough, mechanical cough assist devices are recommended to prevent respiratory complications. Level of evidence, low; benefit, intermediate; grade of recommendation, C

Electrical Stimulation of the Expiratory Muscles

Electrical stimulation of the abdominal muscles can also increase expiratory pressures and has the advantage of not requiring the presence of a caregiver. Coughs produced by electrical stimulation are associated with expiratory flows equal to the manually assisted coughs.[67–69] These results suggest that the technique is worthy of more detailed study and may be a potentially effective modality for assisting spinal cord-injured patients.

Conclusion

The limited data available indicate that in patients with copious secretions (and especially those with CF), the clearance of secretions as assessed by either sputum volume or radioaerosol clearance can be enhanced with a variety of physical therapy procedures and devices. Postural drainage may augment forced exhalation, but the additional value of percussion and vibration are questionable. PEP therapy provides benefits that are comparable to those of forced expiration and postural drainage in selected patients with CF. Manually and mechanically assisted coughing may be beneficial to patients with severe neuromuscular disease and impaired cough. The effect of nonpharmacologic airway clearance techniques on long-term outcomes, such as health-related quality of life and rates of exacerbations, hospitalizations, and mortality is not known at this time. Nevertheless, these techniques are well-entrenched in the management of patients with mucus hypersecretion, especially those with CF.

Recommendation

10. The effect of nonpharmacologic airway clearance techniques on long-term outcomes such as health-related quality of life and rates of exacerbations, hospitalizations, and mortality is not known at this time. The committee recommends that future investigations measure these outcomes in patients with CF, and in other populations with bronchiectasis, COPD, and neuromuscular diseases. Level of evidence, expert opinion; benefit, substantial; grade of recommendation, E/A

Summary of Recommendations

1. In patients with CF, chest physiotherapy is recommended as an effective technique to increase mucus clearance, but the effects of each treatment are relatively modest and the long-term benefits unproven. Level of evidence, fair; benefit, small; grade of recommendation, C

2. In patients with expiratory muscle weakness, manually assisted cough should be considered to reduce the incidence of respiratory complications. Level of evidence, low; benefit, small; grade of recommendation, C

3. In persons with airflow obstruction caused by disorders like COPD, manually assisted cough may be detrimental and should not be used. Level of evidence, low; benefit, negative; grade of recommendation, D

4. In patients with COPD and CF, huffing should be taught as an adjunct to other methods of sputum clearance. Level of evidence, low; benefit, small; grade of recommendation, C

5. In patients with CF, autogenic drainage should be taught as an adjunct to postural drainage as a method to clear sputum because it has the advantage of being performed without assistance and in one position. Level of evidence, low; benefit, small; grade of recommendation, C

6. In patients with neuromuscular weakness and impaired cough, expiratory muscle training is recommended to improve peak expiratory pressure, which may have a beneficial effect on cough. Level of evidence, expert opinion; benefit, small; grade of recommendation, E/C

7. In patients with CF, PEP is recommended over conventional chest physiotherapy because it is approximately as effective as chest physiotherapy, and is inexpensive, safe, and can be self-administered. Level of evidence, fair; benefit, intermediate; grade of recommendation, B

8. In patients with CF, devices designed to oscillate gas in the airway, either directly or by compressing the chest wall, can be considered as an alternative to chest physiotherapy. Level of evidence, low; benefit, conflicting; grade of recommendation, I

9. In patients with neuromuscular disease with impaired cough, mechanical cough assist devices are recommended to prevent respiratory complications. Level of evidence, low; benefit, intermediate; grade of recommendation, C

10. The effect of nonpharmacologic airway clearance techniques on long-term outcomes such as health-related quality of life and rates of exacerbations, hospitalizations, and mortality is not known at this time. The committee recommends that future investigations measure these outcomes in patients with CF, and in other populations with bronchiectasis, COPD, and neuromuscular diseases. Level of evidence, expert opinion; benefit, substantial; grade of recommendation, E/A

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