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AARC Clinical Practice Guideline: Effectiveness of Nonpharmacologic Airway Clearance Techniques in Hospitalized Patients

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Abstract

Airway clearance therapy (ACT) is used in a variety of settings for a variety of ailments. These guidelines were developed from a systematic review with the purpose of determining whether the use of nonpharmacologic ACT improves oxygenation, reduces length of time on the ventilator, reduces length of stay in the intensive care unit (ICU), resolves atelectasis/consolidation, and/or improves respiratory mechanics vs. usual care in 3 populations. For hospitalized, adult and pediatric patients without cystic fibrosis, 1) chest physiotherapy (CPT) is not recommended for the routine treatment of uncomplicated pneumonia; 2) ACT is not recommended for routine use in patients with COPD; 3) ACT may be considered in patients with COPD with symptomatic secretion retention, guided by patient preference, toleration, and effectiveness of therapy; 4) ACT is not recommended if the patient is able to mobilize secretions

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with cough, but instruction in effective cough technique may be useful. For adult and pediatric patients with neuromuscular disease, respiratory muscle weakness, or impaired cough, 1) cough assist techniques should be used in patients with neuromuscular disease, particularly when peak cough flow is < 270 L/min; CPT, positive expiratory pressure, intrapulmonary percussive ventilation, and high frequency chest wall compression cannot be recommended due to insufficient evidence. For post-operative adult and pediatric patients, 1) incentive spirometry is not recommended for routine, prophylactic use in post-operative patients, 2) early mobility and ambulation is recommended to reduce post-operative complications and promote airway clearance, 3) ACT is not recommended for routine post-operative care. The lack of available high level evidence related to ACT should prompt the design and completion of properly designed studies to determine the appropriate role for these therapies.

Key Words

Airway clearance therapy, ACT, chest physiotherapy, CPT, atelectasis, secretion clearance, percussion

Introduction

The mucociliary escalator and cough reflex defend the respiratory system by facilitating secretion clearance and preventing airways obstruction. Healthy individuals produce 10 mL – 100 mL[1] of airway secretions daily, which are cleared by the centripetal movement of the mucociliary escalator.[2] Many factors make it difficult to mobilize and evacuate secretions. The efficacy of the mucociliary escalator is impaired by aging, tobacco use, environmental exposures, and disorders such as bronchiectasis.[3,4,5] Neurodegenerative conditions decrease the ability to cough effectively leading to secretion retention.[6,7,8,9,10]

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Airway clearance therapy (ACT), performed by respiratory therapists and other health care providers, is intended to aid secretion mobilization and expectoration, and to mitigate complications associated with secretion retention. ACT uses physical or mechanical means to manipulate airflow, to mobilize secretions cephalad, and to facilitate evacuation by coughing.[11] Breathing maneuvers, gravity assisted drainage, manual techniques, and mechanical devices can be used in an effort to facilitate secretion mobilization.

Recommending, performing, and educating patients and families on ACT and secretion management are within the respiratory therapist's scope of practice. This therapy is also within the practice of physical therapists, nurses, and others. When possible, therapy should be matched to the patient's disease process, cognitive ability and preferences, the characteristics and limitations of the device or technique, and cost. Clinicians prescribing this therapy and those implementing the therapy must be familiar with the evidence supporting ACT techniques and devices which is often limited.[12,13]

The purpose of this guideline, developed in conjunction with the systematic review by Andrews et al,[14] is to provide guidance to clinicians in the identification, selection, and application of ACT techniques. These guidelines do not include the use of ACT in patients with cystic fibrosis (CF), as this has already been addressed.[11]

Assessment of Evidence

We sought to determine whether the use of nonpharmacologic ACT improves oxygenation, reduces length of time on the ventilator, reduces length of stay in the intensive care unit (ICU), resolves atelectasis/consolidation, and/or improves respiratory mechanics vs. usual care in 3 populations. The ACTs considered are listed in Table 1. Because no high-level

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evidence was available and the recommendations are based on low-level evidence, we have not used a formal guideline development process such as GRADE.[15] Rather, the recommendations are based on a consensus of the committee, informed by a systematic review of the literature,[14] and clinical experience. The systematic review helped frame the issues and allowed for an identification of potential harms.

Hospitalized, Adult And Pediatric Patients Without Cystic Fibrosis

Diseases such as pneumonia, bronchiectasis, COPD, and asthma have the potential to increase airway secretions and endotracheal intubation can impair secretion clearance. Some patients are prescribed ACT for prophylaxis against symptomatic secretion retention (i.e. ineffective gas exchange, atelectasis, dyspnea). Because of its historical prominence and frequent use, chest physiotherapy (CPT) has mistakenly been classified as the gold standard of ACTs.[16,17,18]

The systematic review found no evidence from randomized controlled trials (RCT) to support the use of ACTs to improve oxygenation, reduce length of time on the ventilator, reduce length of stay in the ICU, resolve atelectasis/consolidation, and/or improve respiratory mechanics vs. usual care in this population.[14] Some studies suggest that intrapulmonary percussive ventilation (IPV) may decrease length of stay in the ICU for non-intubated patients with COPD, but insufficient high-level evidence exists to support a recommendation for this therapy.[19,20]

Guidelines from other groups also identified minimal evidence to support the use of ACT in hospitalized patients.[21,22] Based on lower levels of evidence, some guidelines recommend FET

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for COPD patients,[21] ACBT and autogenic drainage for the treatment of bronchiectasis in adults,[22] or oscillating PEP for patients with COPD.[22]

Recommendations supported by low-level evidence:

1. CPT is not recommended for the routine treatment of uncomplicated pneumonia.
2. ACT is not recommended for routine use in patients with COPD.
3. ACT may be considered in patients with COPD with symptomatic secretion retention, guided by patient preference, toleration, and effectiveness of therapy.
4. ACT is not recommended if the patient is able to mobilize secretions with cough, but instruction in effective cough technique (e.g., FET) may be useful.

Adult And Pediatric Patients With Neuromuscular Disease, Respiratory Muscle Weakness, Or Impaired Cough

There are many causes of respiratory muscle weakness and impaired cough including neuromuscular disease (NMD), spinal cord injury, primary neurologic conditions, and generalized weakness. NMD covers a wide range of disorders, with varying onset, rates of progression, and patterns of muscle involvement. Many NMD eventually involve the respiratory muscles.[23] Pulmonary complications are a well-known cause of morbidity and mortality in these patients.[24] Inspiratory muscle weakness decreases the ability to breathe deeply and expiratory muscle weakness decreases the ability to generate the sufficient intra-thoracic pressure during exhalation to cough effectively. While mucus production may be normal, some patients with bulbar muscle involvement may aspirate, leading to airway obstruction and infection. Pediatric

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patients have the additional burden of lower functional residual capacity, increased airway closure, and smaller airway diameter.[23]

No RCT met the criteria for inclusion in the systematic review.[14] However, the American College of Chest Physicians,[21] British Thoracic Society,[22] American Association of Neurology,[25]Center for Disease Control and Prevention,[26] and American Thoracic Society[27] have published guidelines that recommend various ACTs in certain situations. These guidelines are based on low-level evidence and patient benefit is indeterminate. Issues surrounding ACTs in this population include the necessity of a caregiver for assistance, poor technique, tolerance, and lack of effectiveness in some patients.[21]

Several guidelines recommended manual and mechanical cough assist procedures for patients who have a weak cough.[21,22,25,26,27] Mechanical insufflation-exsufflation (MI-E) was cautiously recommended for children with weak cough,[22] strongly recommended in patients with Duchenne muscular dystrophy (DMD),[26,27] and recommended for patients with amyotrophic lateral sclerosis.[25] Based on low-level evidence, it has been suggested that therapy for cough assist should be initiated when peak cough flow is < 270 L/min.[27] Though frequently mentioned for management of patients with NMD, no high level studies address CPT in this population. CPT is often not well tolerated or feasible in these patients. Previously reviewed guidelines do not report any recommendations related to CPT. [21,22,25,26,27] PEP therapy is not recommended by any major medical society for the management of NMD patients. There are some RCTs involving IPV and HFCWC, but the sample sizes are small and evidence to support or reject their use in this population is not sufficient.[28,29,30]

Recommendations supported by low-level evidence:

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1. Cough assist techniques should be used in patients with NMD, particularly when peak cough flow is < 270 L/min.
2. CPT, PEP, IPV, and HFCWC cannot be recommended due to insufficient evidence.

Postoperative adult and pediatric patients

Post-operative pulmonary complications occur in approximately 7% of patients with normal preoperative lung function and more than 70% of those with increased risk factors such as advanced age, history of smoking, obesity, pre-existing chronic lung disease, obstructive sleep apnea, type and duration of surgery, extent and location of surgical incision, and use of a nasogastric tube.[31,32,33] Upper abdominal and thoracic surgeries are associated with the highest complication rates. Post-operative pulmonary complications include atelectasis, respiratory failure and airway infection. Although atelectasis is the most common complication, pneumonia is considered to be the main cause of increased mortality; and these can co-exist.[34] Shallow breathing and weak cough leads to retained secretions and is thought to be a primary contributor.[21,32] Therapies to address post-operative complications include lung volume expansion therapies (e.g., incentive spirometry, IPPB, CPAP) and secretion removal therapies (e.g., CPT, HFCWC, IPV, PEP).

Incentive spirometry (IS) is one of the most common therapies ordered for post-operative patients at risk for post-operative pulmonary complications and in those who develop pneumonia and atelectasis. The systematic review[14] did not include IS, but several recent meta-analyses have been published on this topic. Cochrane systematic reviews found no evidence of benefit for the routine use of IS in patients following coronary artery bypass graft surgery[31] or following upper

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abdominal surgery.[32,36,37] Carvalho[34] et al came to similar conclusions in a review of 30 studies of patients recovering from abdominal, cardiac and thoracic surgery.

The systematic review[14] found that studies focused on CPT in this population did not demonstrate a reduction in the incidence of post-operative pulmonary complications, nor was there a decrease in hospital length of stay. Additionally, no improvement in pulmonary function (FEV_1, FVC, and PEF) was reported with the addition of CPT to routine patient care.[38,39,40,41,42,43,44] The 2 studies of PEP therapy were contradictory and, therefore, there is no clear evidence supporting the use of PEP therapy in this population.[39,44] However, it has been well-documented that early patient mobilization in this population can reduce the incidence of complications.[45,46,47]

The results of the systematic review[14] are similar to other recent reviews. Pasquina et al[37] included 13 trials in a systematic review that compared physiotherapy to a no-intervention control group and concluded that routine physiotherapy was not justified. Another systematic review of strategies to reduce pulmonary complications after non-cardiothoracic surgery concluded that the evidence suggests that any type of lung expansion intervention is better than no prophylaxis, but that no modality was superior to the others, and combined modalities may provide additional risk reduction.[48]

Few if any of the studies in the post-operative population specifically evaluated airway clearance as an outcome. Given the low level of evidence for any ACT therapy, no high-level recommendations can be made at this time.

Recommendations supported by low-level evidence:

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1. Incentive spirometry is not recommended for routine, prophylactic use in post-operative patients.
2. Early mobility and ambulation is recommended to reduce post-operative complications and promote airway clearance.
3. ACT is not recommended for routine post-operative care.

Questions To Consider When Selecting An Airway Clearance Technique Or Device For An Individual Patient

Despite the clinical observation that retained secretions are detrimental to respiratory function and anecdotal associations between secretion clearance and improvements in respiratory function, there is a lack of high-level evidence to support any airway clearance technique. The results of the systematic review of RCTs by Andrews and colleagues[14] are the same in each of the clinical settings evaluated. Specifically, for individuals without CF, airway clearance interventions reviewed provide small benefits in pulmonary function, gas exchange, oxygenation, and need for or duration of mechanical ventilation, but differences between groups were generally small and not significant.

The Andrews et al[14] report does not mean that the device choice for airway clearance in a specific patient does not matter. Given a lack of evidence, we suggest the following process and clinical hierarchy of questions to determine the need for and technique used to perform airway clearance therapy.[12]

1. Investigate the rationale for use of airway clearance therapy. Does the patient have difficulty clearing airway secretions? Are retained secretions affecting gas exchange or lung mechanics? Rather than focusing on the volume of expectorated secretions, attention

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should be placed on the difficulty the patient is having when attempting to mobilize and expectorate airways secretions. Available evidence does not support routine airway clearance therapy in post-operative patients, mechanically ventilated patients, or patients with COPD.

2. Evaluate the potential for adverse effects of therapy. Which therapy is likely to provide the greatest benefit with the least harm? The review by Andrews et al suggests that the risk of harm associated with usual airway clearance techniques is low, although complications may be under-reported.[14]
3. Determine the cost of the therapy. What is the cost of the therapy in terms of the device cost and clinician time to apply or supervise the therapy? Airway clearance techniques can be time consuming for hospital staff. Some devices are expensive for the equipment and supplies. This is particularly important when selecting a device or techniques to be used at home.
4. Inquire about patient preferences. What factors are important to the patient with regard to performing airway clearance therapy? Lacking high-level evidence that any technique is superior to another, patient preference is an important consideration.

When a decision is made to prescribe airway clearance therapy for a patient, the expected outcome and treatment period should be clearly articulated. Desired outcomes or goals for therapy might include an increased (or decreased) volume of expectorated sputum, an improvement in gas exchange, an improvement in radiographic findings, or an improvement in patient-reported symptoms such as dyspnea. If the therapeutic goal is not achieved in the specified time, the therapy should be discontinued. Performing ACT with an ambiguous clinical outcome and continuing the therapy without evidence for benefit is a waste of resources. An n-

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of-1 construct (multiple crossover studies on one individual) is attractive, but might be difficult to implement in the acute care setting.[49,50]

When evidence from high-level RCTs is not available, decisions may be made based on clinical judgment. For example, there is a strong physiologic rationale for the use of airway clearance therapy in patients with neuromuscular disease and a weak cough.[51] Moreover, there are a number of observational studies supporting the use of cough assistive therapies in this patient population. Thus it is reasonable to recommend airway clearance therapy for these patients, with a goal of increased expectorated sputum, and the therapy should be continued if this goal is achieved.

Respiratory secretions trouble clinicians and patients, and standard practice calls for efforts to clear these from the lungs. An important proportion of respiratory therapists' (and others') time is spent in efforts to remove secretions from the lower respiratory tract. In recent years a variety of techniques for secretion clearance have become available. Despite clinical enthusiasm for many of these by both clinicians and patients, there is sparse high-level evidence demonstrating benefit from many of these techniques. As pointed out by Andrews et al,[14] there are a number of methodological limitations of published reports of secretion clearance techniques. Although lack of evidence does not mean lack of benefit, it is desirable to have better evidence to support the practice. Appropriately powered and methodologically sound research is needed. This provides an opportunity for respiratory therapists and others to conduct research on a very important aspect of our practice. To ensure effective therapy for patients and maximize health care resources, the scientific basis for airway clearance techniques must be improved.

Summary

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Anecdotally, routine delivery of ACTs, most notably CPT, to non-CF, hospitalized patients is common. However, the burden of delivering prophylactic ACT (i.e. potential complications, cost of therapy, overutilization of resources for both staff and patient finances) outweigh the perceived benefit. Indeed, no high level evidence was found to substantiate significant benefit on any outcome from the use of ACT in this population.[14] The use of routine prophylactic ACT cannot be supported.

With regard to the NMD population, ACT has traditionally targeted improved cough as a means to prevent and treat pulmonary morbidity. ACT techniques have also been employed during acute respiratory infections to mobilize secretions. However, there is a lack of high-level evidence supporting any of these techniques, despite a large number of observational reports, narrative reviews, and guidelines written on the subject. The Andrews et al[14] systematic review found no trials meeting our criteria on the subject, with most research based on crossover or observational design with small sample sizes, case studies, or anecdotal experience.

When cough is weak, cough assist techniques such as manual or mechanical assisted cough maneuvers may be beneficial.[52] Low level evidence from observational studies suggests that a PCF greater than 160-270 L/min is necessary to generate an effective cough.[25,26] Though the measurement of PCF is more definitive for identifying weak cough, the application of cough assist technique should also be based on the patient's ability to tolerate the therapy and effectiveness noted for each individual patient.

Following upper abdominal and thoracic surgery, important pulmonary complications pose significant risks. Avoidance of these complications is the prudent approach with both appropriate intraoperative ventilation and a post-operative multi-faceted protocol.[53,54,55,56,57] ACT has been used for the prevention and treatment of post-operative pulmonary complications for

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many years. However, there are many causes of atelectasis[58] and the use of ACT in the setting of atelectasis without retained airway secretions does not appear to be effective. This is particularly true in the setting of upper abdominal and thoracic incisions, where performing these maneuvers is likely to increase pain, which further impairs lung function and cough. Time honored therapies without sufficient evidence should be abandoned in favor of multi-faceted approaches that include patient education, collaborative care, and early ambulation.[53,54,55,56,57]

Routine use of IS cannot be supported as a therapy to prevent post-operative complications. Continuous positive airway pressure (CPAP) by facemask can alleviate hypoxemia due to low tidal volumes and airway obstruction and avoid re-intubation but there is no high level evidence that this improves airway clearance.[59] PEP therapy is seen as a simple and less expensive alternative to CPAP. However, the routine use of PEP has no high level evidence supporting its use other than in patients with CF.

Respiratory therapists and others on the healthcare team must face the reality that the ACTs commonly provided for hospitalized patients lack support from high-level studies. In this time of cost containment, we are obliged to provide therapy for which there is sufficient evidence for benefit. This lack of evidence for a commonly administered therapy should sound the siren for clinicians, academic institutions, and funding agencies to collaborate on well-designed studies to determine which ACT are beneficial for hospitalized patients.

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Table 1. ACTs included in the systematic review.

Technique	Abbreviation	Definition
Active Cycle of Breathing Technique	ACBT	Directed coughing technique; relaxed diaphragmatic breathing and deep breathing cycles followed by FET
Chest Physiotherapy	CPT	External chest wall manipulation, which includes one or a combination of or all of the following: percussion, vibration, and postural drainage therapy.
Forced Exhalation Technique	FET	Directed open glottis coughing technique; also called "huffing"
High Frequency Chest Wall Compression	HFCWC	External manipulation through a vest or wrap worn by the patient that is connected to a device using bursts of air to compress the chest wall
Intrapulmonary Percussive Ventilation	IPV	Pneumatically powered, high-frequency short bursts of gas applied at the airway opening (i.e. mask encircling the nose and mouth, mouth, tracheostomy tube)
Mechanical Insufflation-Exsufflation	MI-E	Mechanically applied positive pressure breath followed by negative pressure applied to the airway opening
Positive Expiratory Pressure	PEP	Exhalation against a fixed resistor that creates an increase in airway pressure; includes oscillatory PEP devices such as Flutter®, and Acapella®