Assisted Cough Techniques

Site Applicability

All VCH & PHC sites – acute, community, residential

Practice Level

Discipline	Level of Training
Physical Therapist (PT)	Entry level practice
Respiratory Therapist (RT)	Entry level practice
Registered Nurse (RN)	Within scope with adequate training*
Licensed Practical Nurse (LPN)	Within scope with adequate training*
Occupational Therapist (OT)	Within scope with adequate training*
Patient Care Aide (PCA)	Advanced skill delegated patient specific task with supervision
Rehabilitation Assistant (RA)	Advanced skill delegated task with supervision
Residential Care Aide (RCA)	Transfer of professional task – client specific advanced skill
Home Support Worker (HSW) / Community Health Worker (CSW)	Transfer of professional task – client specific advanced skill

* Adequate training is defined as the training of the knowledge and skills required to perform this technique, recent and the opportunity to apply the skill with mentorship from an instructor experienced in this technique (for a checklist see Appendix B). The training should include evaluation to ensure that the individual performs the technique safely and effectively.

Note:

- This document is not intended to function as "stand-alone training" for health care providers who do not receive training in assisted cough as a component of their pre-licensure training, continuing education or during the care of a specific patient.
- Assisted cough requires a combination of knowledge and practice in both clinical decision-making and physical application of this technique - familiarity with the content of this document and its accompanying resources is insufficient for clinical application of this technique.
- The intent of this document is to provide background and reminders for those already trained in the technique.
- Annual practice in application is recommended for those who have little exposure to the patient populations with whom assisted cough is pertinent.

Policy Statement

An assisted cough should only be performed by trained health care professionals as per their scope of practice. Family members and caregivers who have received training, specific to a given patient, by a health care professional can also perform an assisted cough in the home setting. Healthcare providers within a hospital setting should check the policy of their organization regarding family members participating in care provision.

Need to Know

An Assisted Cough Technique is used when a patient is unable to generate sufficient expiratory force to produce an effective cough to clear secretions. This may be due to neurological impairment, fatigue and/or weakness in association with tenacious or excessive secretions.

Descriptions:

- **Assisted Cough:** The practice of pushing the abdomen and /or thorax with sufficient force to generate the positive airway pressure needed to expel mucus (Reid et al 2009).
- **Normal Cough:** A deep inspiratory breath is followed by forced expiration with a closed glottis, which then opens to allow for rapid expiration.
  - Peak cough flow (PCF) is generally greater than 500 L/min (Toussaint et al, 2009 in Jaeger et al, 1993)
  - PCFs of between 300 to 700L/min have been reported in adult and pediatric literature (Jaeger et al, 1993).
  - **Minimal PCF [peak cough flow] for 'effective' cough:**
    - **Adults:** Flows of less than 270 L/m are an indication for assisting cough [in adults] [Bach et al, 1997).
    - **Pediatrics:** In children less than 12 years old, the PCF generated is dependent on the child's age and sex. Therefore age and sex should be taken into account when trying to determine an acceptable minimal PCF. Currently there are no reported minimal PCF values for children under 12 years of age. [Bianchi et al, 2008]
    - The primary inspiratory muscle is the diaphragm (innervation C3-5). The most important expiratory muscles are the abdominals (innervation T6-L1). The intercostals increase the force of inspiration and expiration (innervation T1-11). (refer to Appendix C) (Reid et al 2009)
- **An ineffective cough can lead** to retained secretions, which can adversely effect gas exchange and/or inspiratory volume; increase risk of infection/pneumonia; cause increased work of breathing and respiratory distress, and lead to atelectasis, lobar collapse/consolidation and possibly respiratory failure. (Reid et al 2009).
- **Supported Cough:** A procedure by which the clinician augments the client's cough effort by the manual application of pressure to the upper abdomen and/or thorax during the client's voluntary expiration.

Indications for use of assisted cough:

- **Assisted cough techniques** are used with clients who are unable to effectively clear secretions due to neurological impairment and/or muscle weakness
- **Typical client populations:** Clients with neurological impairment to inspiratory and expiratory muscles (e.g. Spinal cord injury (above T12), Guillian Barre Syndrome).

Risks associated with assisted cough:

- **Assisted cough has inherent risks** associated with the maneuver. Risks to the client may include: pain, fractured rib(s), pneumothorax, hemothorax, or perforated bowel. (Reid et al 2009)
- **Temporarily stopping feeds and insulin:** If the patient is receiving feeds (and insulin infusion) discuss with the interdisciplinary team whether temporarily stopping these shortly before and during performance of assisted cough techniques should be considered for the patient to prevent aspiration and maintain sugar control.
- **Pediatric patients** – use caution with amount of force, chest walls tend to be quite compliant.

Precautions and Contraindications:

- **Contraindications:** inferior vena cava filter (Pearl 2001, Reid et al 2009). May be overridden by a medical order.

Table 1: Precautions/Special Considerations

Special Considerations/ Precautions	Suggested alternate methods (In consultation with interdisciplinary care team)
Abdominal aortic aneurysm (AAA)	Apply pressure to thorax and not abdominal area
Abdominal trauma and/or recent abdominal surgery	Apply pressure to thorax and not abdominal area
Acute resp/cardiac/hemodynamic instability	Ensure client can hemodynamically tolerate procedure monitor RR, HR, BP, SpO2
Bowel obstruction	Apply pressure to thorax and not abdominal area
Colostomy bag	Apply pressure to thorax and not abdominal area
Empyema	Consult with physician
Fragile or rigid thoracic cage (e.g. osteoporosis, rib metastases, ankylosing spondylitis, kyphoscoliosis)	Apply pressure to abdomen and not thorax
Gastric reflux / hiatus hernia	No head down position unless performed with nasogastric suction
Gastrostomy / jejunostomy tubes	Apply pressure to thorax and not abdominal area
Increased intra-cranial pressure (ICP)	Monitor ICP, consult with physician
Pregnancy	Apply pressure to thorax and not abdominal area
Pediatric patients	Apply pressure to thorax and not abdominal area, unless contraindicated. Empty stomach, gastric feeds off at least ½ hour prior to treatment.
Surgical interventions to thorax (e.g. sternotomy, thoracotomy, chest tubes)	Do not apply pressure over affected area. No thoracic cough done on post-sternotomy clients
Trauma to thorax (e.g. fractured ribs, flail segment, pulmonary contusion, cardiac contusion, acute dysrhythmia, pericardial effusion, pneumothorax)	Do not apply pressure over affected area
Unstable artificial airway	Ensure stability before proceeding
Unstable spine	Follow spine precautions (e.g. maintain neutral spine)
Ventilated client	See section below

Delegation of Assisted Cough:

- **Assisted coughing can be** delegated to a paid unlicensed care provider (UCP) in the community with appropriate training from a licensed health care provider, usually the physical therapist. This typically requires a letter of delegation and ongoing monitoring by the licensed health care provider. UCPs may include home support workers, care aides, group home workers, and school and student support workers. Adhere to organizational policies specific to the given UCP role regarding training, assignment, evaluation and monitoring of tasks.

Equipment & Supplies

- Personal protective equipment as per Infection control guidelines (VCH and PHC)
- Supplemental equipment as indicated: supportive surface e.g. bed or chair, suctioning equipment, oxygen, pulse oximeter, Resuscitation Bag / Bag-Valve Mask (BVM) e.g. Ambu-bag.

Practice Guideline

1. **Observation**
   - Breathing pattern
   - Work of breathing
   - Respiratory rate
   - Colour, amount and consistency of sputum
   - Pallor
   - Level of alertness
2. **Objective findings**
   - Palpation
     - Determine flexibility of ribcage (if rigid, hand placement for cough should be on abdomen)
     - Assess degree of use of diaphragm, intercostals and accessory muscles
     - Location of obvious secretions
   - Auscultation
   - Oxygen requirements (FiO_2)
   - Oxygen saturation (SpO_2)
   - Arterial blood gas (ABG)
   - Respiratory rate (RR)
   - Vital capacity (VC)
   - Neurological assessment – to determine innervation and activation of inspiratory and expiratory muscles
   - Assess for any precautions or contraindications identified in Table 1.
3. **Monitoring as necessary**
   - SpO_2
   - End tidal carbon dioxide ($ETCO_2$) (available in ER and Critical Care Units only)
   - Electrocardiogram (ECG)
   - Heart rate (HR) and blood pressure (BP)
   - Ensure emergency equipment is available for ventilated patients including Resuscitation Bag / Bag-Valve Mask (BVM) and airway equipment as needed.

Ventilated Clients

Assisted cough may be performed on ventilated clients. Consider the following in the clinical decision of how to proceed for a given patient (consult with team members and/or an educator if unsure):

- ***Inspiratory Volume Requirements***
  - A deep inspiration improves the efficacy of the cough maneuver. Assess the ability of the client to assist with a deep inspiration and/or provide pressure/volume assistance through the ventilator or Resuscitation Bag / Bag-Valve Mask (BVM) as required.
- ***Ventilator Disconnection***
  - Determine if the ventilator is to be left connected during the procedure or if manual ventilation is more appropriate. This may be determined by suctioning and/or oxygenation requirements, adjunctive therapy, ventilator capability, alarm settings, or manual ventilation requirements. Consult a physiotherapist or respiratory therapist if unsure.
  - A ventilated patient is likely to have impaired ability to breathe on their own, consider the need for increased rest periods on the ventilator or during manual ventilation (bagging) during the assisted cough procedure.
- ***Ventilator Monitoring***
  - Ensure ventilator monitoring during and post-procedure. This includes checking alarms are active and appropriately set (alarm silence feature should be reset after assisted cough), pressures/volumes are compared to previous levels, artificial airway is in place and secure, tubing connections are secure, and all parameters have been reset to previous levels.
- ***Humidification Requirements***
  - Ensure adequate humidification is being provided through the ventilation system in use. Meeting the client's humidification requirements will help to thin the secretions and improve mucociliary clearance.

Planning:

1. Consider body mechanics of caregiver. Consider height and stability of work surface. Take advantage of using own bodyweight (weight shifts) and consider the height of the working surface (i.e. beds, couches, chairs, etc.). Review the "top ten list" to limit potential risk of injury to the person performing the technique. Ensure wrists are close to a neutral position, elbows are straight not locked and palms of hand are in contact with the client.
2. Determine number of caregivers required for an effective cough as determined by client needs (i.e. 1 person vs. 2 person technique, suctioning, adjunctive devices such as IPPB or insufflator-exsufflator, ventilator parameter alterations, manual ventilation, etc.).
   Note: Use 2 persons if:
   1. unable to achieve effective assisted cough with only 1 person;
   2. the chest size is large and
   3. the patient requires oxygenation (e.g. bagging) and suctioning.
3. Determine need for abdominal and/or thoracic hand placement (see precautions).
4. Determine need for supplementing inspiration: Assisted cough has been shown to be more effective if there is a volume of 60 to 90% of the Total lung capacity (CTS 2011). In clients who cannot generate this volume independently, modalities can be used to augment the client's effort and increase lung volume recruitment. These devices may include Resuscitation Bag / Bag-Valve Mask (BVM) or breath-stacking with a BVM or Intermittent positive pressure breathing (IPPB).
5. Set up suction equipment if required.

Intervention:

***Note: The procedure described below is appropriate for both adult and pediatric populations except for a small variation in the hand position for the pediatric patient.**

- For babies/infants, depending on the size of the child's chest, the clinician should use both hands or palmar surface of 2 to 3 fingers placed flat on upper chest or lateral chest under axillae.
- For larger children clinicians should use hand positions shown in Figures 1 or 3 (see description on page 7).

1. **Wash hands and don personal protective equipment**.
2. **Preoxygenation**:
   Assess oxygen requirements and pre-oxygenate as necessary (e.g. if the patient has a history of desaturating during this technique; if the patient has a spinal cord lesion above C5 and has a history of vasovagal responses). Ensure oximetry is adequately monitored throughout procedure if the client has the potential to decompensate.
3. **Explain the procedure** to the client and obtain consent.
4. **Position client** according to needs based on assessment findings. This procedure is most effective when a client is supine or side lying. It can be modified to be performed in a sitting position but may not be as effective as the secretions must be moved upward against gravity and caregiver position may not be as advantageous depending on the chair. Take care to consider your body mechanics. When the client is in a wheelchair you may decide to position the chair up against a wall or bed with brakes on to reduce bouncing of the chair.
5. **Landmark xiphoid, umbilicus and ribcage** and place hands on client. (See pictures below)
6. **Palpate breathing pattern and coordinate with the client and/or secondary caregiver** on timing of breaths and assisted coughs. Client will ideally participate in promoting synchronicity with inspiration, expiration and cough.
   - If there are multiple clinicians/caregivers involved in the technique, a lead should be identified to assist in timing of the technique
7. Ask patient to take a specified number of breaths (i.e. 2 or 3) and to cough on the following expiration. Verbal cuing will ensure timing of breaths and cough.

8. **Encourage client to take a deep breath** with or without supplemental modalities. On exhalation, apply pressure with sufficient force to create an effective cough.
    - If the pressure applied is too little, the cough may be ineffective and there is a risk of patient and caregiver fatigue, as more attempts will be required to clear secretions.
    - If the pressure is too forceful, it may cause pain or trauma and the client may be reluctant to continue.
9. When **applying pressure** to mimic the action of the intercostals muscles; the direction of the force is inward and downward as in the bucket handle movement of the ribs. (as seen in the adult videos).

    When applying pressure to mimic the action of the abdominal muscles; the direction of the force is inward toward the spine and upward toward the diaphragm (Note abdominal pressure is not used with pediatric clients).
10. **Keep wrists, shoulders and back as neutral as possible and elbows almost straight**, not locked. Prevent twisting through the spine. Transfer pressure for the cough using your legs, shifting weight from your back leg to your front leg vs. pushing from your upper body and arms.
11. **Ensure the client's body is not forced upward** against the support surface.
12. **The force should be constant for the full expiratory period without vibration or shaking**.
    - Some pediatric patients can not follow instructions to perform single cough, they do multiple short repeat coughs on a single breath – in this case, follow their lead and compress with each repeat mini-cough. This can end up looking like a very coarse vibration
13. **Repeat assisted coughs as necessary** for mucosal clearance while monitoring client tolerance.
14. **Upon completion**, return client to comfortable position.
15. **Remove personal protective equipment and wash hands**.

Assisted Cough Technique Options (Adult patient):

Figure 1A: One hand on the ribs, one hand between the xiphoid and umbilicus

Figure 1B: Alternate hand placement

Figure 2: One person abdomen only

Figure 3: One person lower thorax

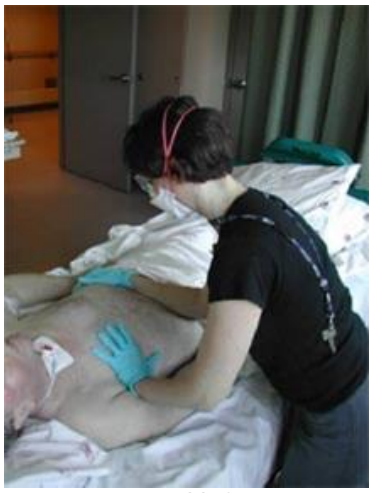

Figure 4: One person with forearm on abdomen, hand on thorax

Figure 5: One person with forearm on thorax, hand on abdomen

Figure 6: Two people on abdomen and thorax, hand over hand

Figure 7: Two people on abdomen and thorax, not hand over hand

Figure 8A: 2 person technique – 1 p on thorax, 1 on abdomen and thorax. NB: The bed is too high

Figure 8B: 2 person technique, alternate view: 1 p on thorax, 1 p on abdomen and thorax

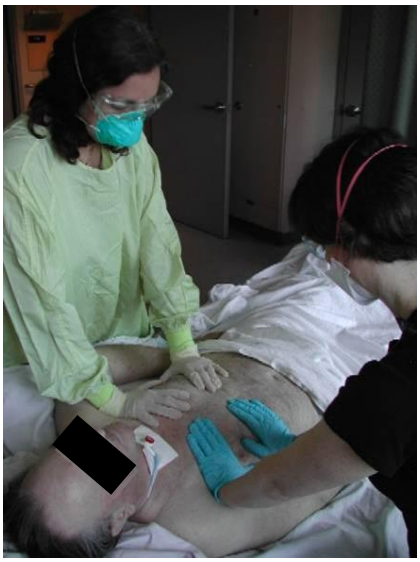

Figure 9: Two person technique – both sets of hands on thorax

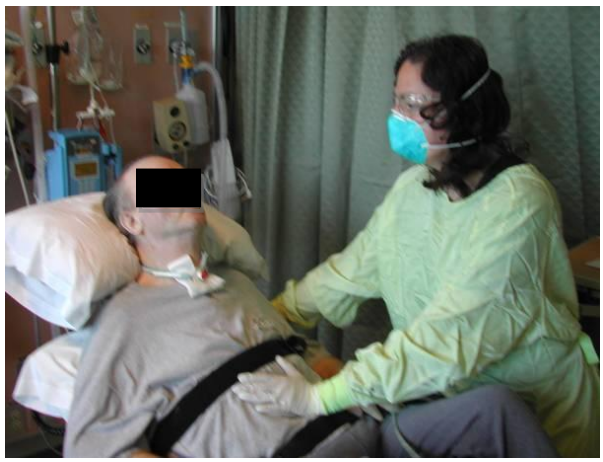

Figure 10: One person chair technique

Assisted Cough Technique Options (Pediatric patient):
on small chests one may need to use only the palmar surface of 3-4 fingers in contact with the thorax
Abdominal thrust is avoided in pediatrics

Figure 11A: use palmar surface of 3-4 fingers placed on either side of upper chest

Figure 11B: use palmar surface of fingers and/or hands placed laterally on chest just under axillae

Figure 12: use palmar surface of 3-4 fingers/hand on upper/front of chest with other fingers/hand supporting posterior chest

Video demonstrations of Assisted Cough Technique Options:	
VIDEO 1: What NOT to do Vibrations (8 secs)	**VIDEO 2:** 2 person N95 mask (27 secs)
VIDEO 3: 2 person chair (28 secs)	**VIDEO 4:** 1 person chair (14 secs)

Expected Patient/Client/Resident Outcomes

- The patient will clear secretions with the help of the assisted cough technique. The objective is to improve oxygen saturation; improve breath sounds on auscultation; and improve and/or reduce work of breathing.

Patient/Client/Resident Education

- The patient should be educated as to why they require an assisted cough technique to be performed and its expected outcomes.
- The patient should also be aware of the physical factors contributing to his/her inability to perform an adequate cough.
- When multiple clinicians are involved in performing the Assisted Cough Technique, the patient should be instructed to take deep breaths and time the exhalation/cough with the count of the person leading the Assisted Cough technique.
- During rehabilitation, a person with a spinal cord injury is educated about altered respiratory function, problem recognition, and treatment options. Part of the process is empowering the person to direct his or her own care, for example suggesting to the caregiver different hand placement, increasing the amount of force, and timing to make an assisted cough more effective.

Evaluation

- The patient should be evaluated to determine if the expected outcomes have occurred. In the event that the patient's oxygen saturation, breath sounds on auscultation or work of breathing to not improve, an alternative form of secretion clearance should be considered, such as suctioning, breath stacking, manual hyperinflation, or intubation.

Site Specific Practices

- No site specific practices exist for this technique.

Documentation

The following should be documented in ID notes, nurse's notes (or other appropriate place)

- VS (SpO_2, HR, BP, RR)
- Position
- Number of care providers required
- Equipment required
- Hand position, frequency, duration
- Amount of secretions
- Any client specific techniques
- Client's response to procedure
- Any related procedures (e.g. postural drainage, oxygenation, suctioning)

Related Documents

- R-320: Lung Volume Recruitment with a Modified Manual Ventilation Unit
- R-315: Lung Volume Recruitment with the Cough Assist Device™
- R-310: Lung Volume Recruitment with the Bird Mark 7 Series Ventilator
- O-120: Oxygen Therapy: Initiation and Maintenance
- O-130: Oxygen Therapy and Respiratory Care Reference Manual
- R-270: Tracheal Suctioning - Closed System
- P-340: Pharyngeal Airways – Insertion, Removal and Tracheal Suctioning

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Appendix A:

Top Ten Tips

Safe Body Mechanics during Assisted Cough

1. **Work as a team** and get help as needed – one, two or even three clinicians may be required, based on client assessment.
2. **Communicate roles clearly** (e.g. hand positioning, timing of the cough).
3. Remember **Quality not Quantity** is important. To reduce fatigue, change roles or change sides if required to perform task repetitively through the day.
4. **Check the equipment**. Ensure brakes are on bed or wheelchair.
5. **Adjust bed height**. Set bed to thigh level with legs slightly bent in a forward-back stance. Back should be fairly upright with a slight bend at the hips.
6. *Stay Stable!* ***Use a wide stance at about 45 degrees to the bed in line with the direction of push. If the patient seems too far away, place the knee (closest to client) on the bed, at the client's hip. Try not to twist.***
7. **Stay neutral!** Keep your hips, back and shoulders in line with the direction you are pushing. Don't twist through your spine.
8. **"Button up"** by tucking your elbows in close and minimizing your reach.
9. Use a **weight shift**. Transfer force for the cough using your legs, shifting weight from your back leg to your front leg. Keep your back neutral. Bend slightly at your hips.
10. **Handle with Care**. Protect your wrists by keeping hands in line with the rest of your arms, as shown here (2 person assist). Don't 'lock' your elbows.

Minimize **<u>your</u>** risk factors for Musculoskeletal Injury!

MSIP Team
June 2006

Appendix B:

Performance Checklist
Assisted Cough Technique

Name: _____ Date: _____

Assessor: _____ Date & Worksite: _____

The caregiver will perform the above skill consistent with the performance checklist and demonstrate knowledge of all principles, contraindications and precautions associated with performing this clinical skill.

The Caregiver Demonstrates	Check box	Comments
Understanding of the indications for performing an assisted cough		
• Ineffective cough due to neurological deficit (Intercostals and abdominals)	☐	
• Need to clear secretions	☐	
Understanding of the contra-indications and precautions for performing an assisted cough		
• Inferior vena cava filter	☐	
• Thoracic limitations	☐	
• Abdominal limitations (See Table 1 in CPD)	☐	
Technique:		
• Clinical reasoning for required supplemental treatments identified	☐	
• Patient position: supine, side lying, sitting.	☐	
• Caregiver positioning: – height of surface, biomechanical advantage of using body weight, weight shift, limit trunk rotation, elbows and wrists not locked.	☐	
• Hand position options – abdominal and/or thoracic	☐	
• One person/two person options	☐	
• Coordination with two person technique	☐	
• Initiation of cough by client	☐	
• Amount of pressure sufficient to clear secretions without causing harm.	☐	
• No shaking/vibrations	☐	
• Ongoing monitoring of tolerance of procedure e.g. SpO_2.	☐	
• Identify that the number of repetitions determined by client's fatigue level and effective clearance of secretions	☐	
Evaluation of effectiveness		
• Subjective report from client, amount of secretions cleared, SpO_2, decreased SOB, auscultation findings.	☐	

Assessor Sign off: _____ Date: _____

Appendix C: Peak Cough Flow Reference Values for Ages 4 – 18

TABLE 2 Percentile values of cough peak flows (liters/min) by gender and age

	Females						
Age, yrs	5th	10th	25th	50th	75th	90th	95th
4	110	112	124	147	179	202	209
5	125	132	171	185	219	245	273
6	161	161	191	230	242	284	317
7	179	200	228	247	265	302	330
8	200	219	270	299	321	340	351
9	270	270	290	311	347	369	369
10	270	284	299	330	361	380	399
11	296	299	347	380	399	441	478
12	305	340	361	399	412	450	459
13	311	330	361	395	441	508	545
14	361	372	399	428	478	518	561
15	344	384	424	469	508	550	596
16	358	412	428	469	508	550	626
17	369	416	433	469	513	550	633
18	399	420	441	488	513	556	639
	Males						
Age, yrs	5th	10th	25th	50th	75th	90th	95th
4	130	132	143	162	194	226	230
5	138	153	179	194	226	262	270
6	166	171	204	226	250	279	293
7	200	211	235	270	299	340	351
8	215	247	279	299	321	340	347
9	217	237	293	311	340	372	424
10	250	260	296	321	351	380	428
11	290	299	340	369	399	420	441
12	311	317	334	369	399	450	498
13	321	337	392	450	518	567	578
14	380	395	498	608	672	713	750
15	380	428	534	633	706	788	829
16	493	518	539	652	713	728	871
17	498	545	561	645	846	898	944
18	518	545	602	728	880	898	944

Table taken from: Bianchi C, Baiardi P (2008). Cough peak flows: Standard values for children and adolescents. Am J Phys Med Rehab 2008 Jun:87(6):461-7

Appendix D: Complete Article Reference List

Year	Author	Title
2011	Canadian Thoracic society	Home mechanical ventilation - A Canadian thoracic society clinical practice guideline
2010	Bach	Extubation of patients with neuromuscular weakness
2009	Ambrosino	Chronic respiratory care for neuromuscular diseases in adults
2009	Toussaint et al	Limits of effective cough-augmentation techniques in patients with neuromuscular disease
2009	Reid et al	Physiotherapy secretion removal techniques in people with spinal cord injury: a systematic review
2008	Bianchi	Cough peak flows: Standard values for children and adolescents
2008	Suri	Pneumothoax associated with mechanical insufflation-exsufflation and related factors
2008	Ishikawa	Cough augmentation in Duchenne muscular dystrophy
2008	Lee	Surface functional electrical stimulation of the abdominal muscles to enhance cough and assist tracheostomy decannulation after high-level spinal cord injury
2008	Gollee	Automatic electrical stimulation of abdominal wall muscles increases tidal volume and cough peak floor in tetraplegia
2008	Fauroux	Physiologic benefits of mechanical insufflation-exsufflation in children with neuromuscular diseases
2007	Homnick	Mechanical insufflation-exsufflation for airway mucus clearance…includes discussion
2007	Salmons	A control system for automatic electrical stimulation of abdominal muscles to assist respiratory function in tetraplegia
2007	Gollee	A control system for automatic electrical stimulation of abdominal muscles to assist respiratory function in tetraplegia
2007	Spivak	Electromyographic signal-activated functional electrical stimulation of abdominal muscles: the effect on pulmonary function in patients with tetraplegia
2007	Schmitt	Survey of use of the insufflator-exsufflator I patients with spinal cord injury
2006	Panitch	Airway clearance in children with neuromuscular weakness.
2006	Grimm	Salmeterol improves pulmonary function I persons with tetraplegia
2006	Sapienza	Respiratory muscle strength training: functional outcomes versus plasticity
2006	Liszner	Cough assist strategy for pulmonary toileting in ventilator-dependent spinal cord injured patients
2006	Brown	Respiratory dysfunction and management in spinal cord injury
2006	DiMarco	Spinal cord stimulation: a new method to produce an effective cough in patients with spinal cord injury
2006	Dohna-Schwake	IPPB_asissted coughing in neuromuscular disorders
2006	Kang	Relationship between inspiratory muscle strength and cough capacity in cervical spinal cord injured patients
2006	McCool	Nonpharmacologic airway clearance therapies: ACCP evidence-based clinical practice guidelines
2006	Cheng	Effect of neuromuscular electrical stimulation on cough capacity and pulmonary function in patients with acute cervical cord injury
2005	DiMarco	Restoration of respiratory muscle function following spinal cord injury. Review of electrical and magnetic stimulation techniques.
2005	Severa	Alternatives to endotracheal intubation for patients with neuromuscular diseases
2005	Kang	Assisted cough and pulmonary compliance in patients with Duchenne muscular dystrophy

Year	Author	Title
2005	Trebbia	Cough determinants in patients with neuromuscular disease
2005	A journal of Orthopaedic Nursing March	A review of respiratory management in spinal cord injury.
2004	Bach	Ventilator weaning by lung expansion and decannulation
2004	Bianchi	Efficacy of glossopharyngeal breathing for a ventilator-dependent, high-level tetraplegic patient after cervical cord tumor resection and tracheotomy
2004	Creasey	Clinical applications of electrical stimulation after spinal cord injury
2004	Perrin	Pulmonary complications of chronic neuromuscular diseases and their management
2004	Lapin	Assisted cough devices
2003	Toussaint	Effect of intrapulmonary percussive ventilation on mucus clearance in Duchenne muscular dystrophy patients: a preliminary report
2003	Mustfa	Cough augmentation in amyotrophic lateral sclerosis
2003	Lahrmann	Expiratory muscle weakness and assisted cough in ALS
2002	Gomez-Merino	Duchenne muscular dystrophy: prolongation of life by noninvasive ventilation and mechanically assisted coughing
2002	Slonimski	Atelectasis and mucus plugging in spinal cord injury: case report and therapeutic approaches
2002	Taylor	Electrical stimulation of abdominal muscles for control of blood pressure and augmentation of cough in a C 3/4 level tetraplegic
2002	Warren	Glossopharyngeal and neck accessory muscle breathing in a young adult with C2 complete tetraplegia resulting in ventilator dependency
2002	Whitney	Assisted cough: a new technique
2001	Pearl	Small bowel perforation after a quad cough maneuver
2001	Sivasothy	Effect of manually assisted cough and mechanical insufflation on cough flow or normal subjects, patients with chronic obstructive pulmonary disease (COPD), and patients with respiratory muscle weakness
2001	Lin	Functional magnetic stimulation for conditioning of expiratory muscles in patients with spinal cord injury
2001	Sadowsky	Electrical stimulation in spinal cord injury
2000	van Der Schans	Efficacy of coughing in tetraplegic patients
2000	Dicpinigaitis	Baclofen-induced cough suppression in cervical spinal cord injury
2000	Kang	Maximum insufflation capacity: vital capacity and cough flows in neuromuscular disease
2000	Lin	Cough threshold in people with spinal cord injuries
1999	Fujiwara	Expiratory function in complete tetraplegics: study of spirometry, maximal expiratory pressure, and muscle activity or pectoralis major and latissimus dorsi muscles
1999	Dicpinigaitis	Cough reflex sensitivity in subject with cervical spinal cord injury
1999/2000	Nelson	Noninvasive mechanical ventilation for children and adolescents with spinal cord injuries
1998	Lin	Functional magnetic stimulation for restoring cough in patients with tetraplegia
1998	Lin	Effects of an abdominal binder and electrical stimulation on cough in patients with spinal cord injury
1998	Estenne	Effects of abdominal strapping on forced expiration in tetraplegic patients
1997	Zupan	Effects of respiratory muscle training and electrical stimulation of abdominal muscles on respiratory capabilities in tetraplegic patients
1997	Hanayama	Amyotrophic lateral sclerosis. Successful treatment of mucous plugging by mechanical insufflation-exsufflation.

Year	Author	Title
1997	Wang	Cough in spinal cord injured patients: the relationship between motor level and peak expiratory flow
1997	Yarkony	Medical grand rounds. Cough in tetraplegia
1996	Massery	Manual breathing and coughing aids patients with paralytic or restrictive ventilatory insufficiency
1995	Bach	Noninvasive long-term ventilatory support for individuals with spinal muscular atrophy and functional bulbar musculature
1994	Estenne	Evidence of dynamic airway compression during cough in tetraplegic patients
1993	Jaeger	Cough in spinal cord patients: comparison of three methods to produce cough
1993	Bach	Mechanical insufflation-exsufflation. Comparison of peak expiratory flows with manually assisted and unassisted coughing techniques
1993	Bach	Airway secretion clearance by mechanical exsufflation for post-poliomyelitis ventilator-assisted individuals
1993	Linder	Functional electrical stimulation to enhance cough in quadriplegia
1992	Estenne	Action of the diaphragm during cough in tetraplegic subjects
1991	Biering-Sorensen	Effect of respiratory training with a mouth-nose-mask in tetraplegics
1990	Kocan	Pulmonary considerations in the critical care phase
1990	Estenne	Cough in tetraplegic subjects: an active process
1989	Balshi	Complications of caval interruption by Greenfield filter in quadriplegics
1984	Braun	Improving the cough in patients with spinal cord injury
1983	Clough	Glossopharyngeal breathing: its application with a traumatic quadriplegic patient
1981	Alvarez	Respiratory treatment of the adult patient with spinal cord injury
1966	Kirby	An evaluation of assisted cough in quadriparetic patients
1987	Massery	An innovative approach to assistive cough techniques