Respiratory

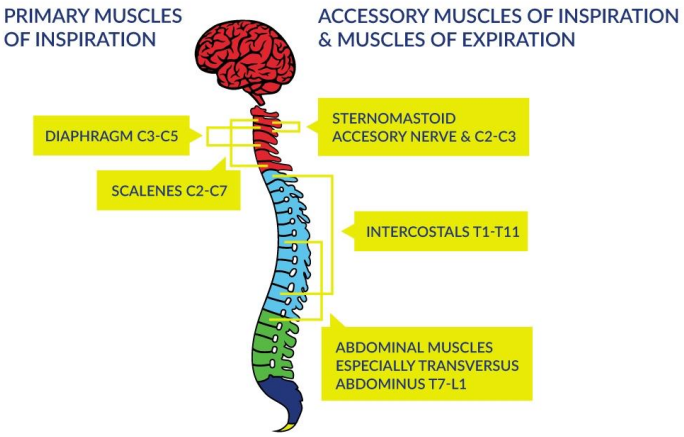
Respiratory complications are one of the most common causes of mortality following a spinal cord injury (SCI). The extent of respiratory compromise following a SCI can be determined by the neurological level of injury (NLI) and the motor and sensory function. Higher levels of injury have more difficulty and impairments relating to the ability to take a deep breath in and effectively cough. Due to the risks of respiratory compromise, management should always be the priority for individuals with a new SCI.

Following a new SCI, respiratory failure is highest in the first 24-72 hours post injury. For cervical lesions it is important to consider the surgical procedure performed. Anterior fixations may be associated with increased sputum production post operatively due to the pressure placed on the recurrent laryngeal nerve.

A chest infection for an individual with tetraplegia can be life threatening, requiring extremely vigorous and regular chest physiotherapy. Therefore, prevention is the key focus in the acute stages.

Muscles of respiration

1. Diaphragm
2. Intercostals
3. Abdominals
4. Accessory muscles
    - Scalenes
    - Pectoralis minor and major
    - Sternocleidomastoid



Objective assessment

- Observation of respiratory musculature
- Respiratory rate
- Auscultation and palpation
- Breathing pattern
- Voice
- Effectiveness and quality of cough
- Sputum (colour, thickness and amount)
- Investigations (chest x-ray, ABGs)

Respiratory Function Test (RFT)

Other factors to be taken into consideration:

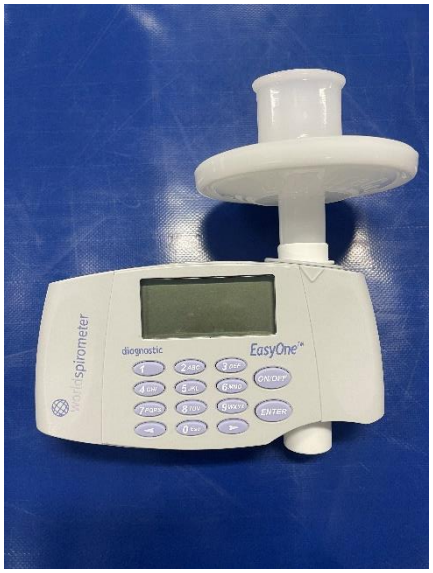
- Pre-existing respiratory conditions

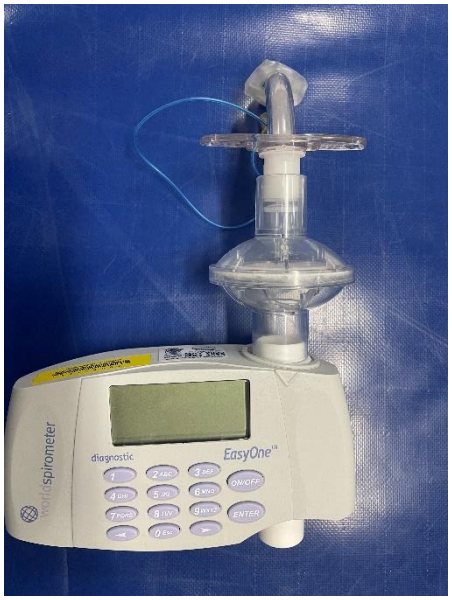
- Drowsiness
    - Analgesia, sleep deprivation or CO2 retention will contribute to a lower respiratory drive and breathing will likely be more shallow
- Chest trauma (i.e., fractured ribs or sternum, pneumothorax or pulmonary contusion)
- Aspiration
    - This can cause airway irritation leading to chronic sputum production
- Disruption of the sympathetic nervous system leading to:
    - Blockage of nasal passages (Guttmans sign), which has implications for non-invasive ventilation options
    - Altered cardiac function leading to increased risk of pulmonary oedema
    - Decreased blood pressure and thermoregulation

Measuring Respiratory Function Tests (RFTs)

Measuring vital capacity (VC) or forced vital capacity (FVC) will establish a baseline which can then be used to monitor for signs of deterioration. Vital capacity is a measure of overall pulmonary function. RFTs can be measured via an endotracheal tube (ETT), tracheostomy or mouthpiece. Two devices are pictured below with set ups for mouthpiece and tracheostomy.

EasyOne Spirometer





Wright Spirometer

Management

Respiratory complications are related to three possible issues:

1. Reduced inspiratory volume (ability to take a deep breath in)
2. Reduced expiratory capacity (ability to cough)
3. Fatigue

Positioning

The best position to assist respiratory function in an individual with a new SCI is supine. This position will allow the diaphragm to be in a gravity eliminated position to improve its function and excursion.

Reduced inspiratory volume

Problem:

Relating to the lack of lateral expansion of the chest wall, the paralysis of the inspiratory musculature and stiffness/immobility

Optimal management:

Positive pressure

- Intermittent positive pressure breathing (IPPB)
- Biphasic posture airway pressure (BiPAP)
- Manual hyperinflations
- Cough assist machine
- Breath stacking/Lung Volume Recruitment)

Other techniques

- Deep inhalation with a hold
- Use straws
- Blow bubbles
- Incentive spirometry

Manual techniques

- Stretch facilitation
- Rib springing

Reduced expiratory capacity

Problem:

Relating to the inhalation insufficiency and the lack of force from the abdominal muscles to expel air quickly

Optimal management:

- Aim to facilitate inhalation and forced exhalation

Positive pressure

- Intermittent positive pressure breathing (IPPB)
- Biphasic posture airway pressure (BiPAP)
- Manual hyperinflations
- Cough assist machine
- Breath stacking

Manual techniques

- Expiratory vibrations, percussion, manual assisted cough

Respiratory fatigue

Problem:

Result of the neurological injury and the increased work of breathing to the inspiratory and expiratory muscles

Optimal management:

- Aim to reduce the effort required to breathe

These patients may benefit from use of IPPB to manage their fatigue. If the patient is deteriorating, they may benefit from breaks with non-invasive ventilation (NIV) or intubation

Methods of Coughing

Movement

- Force is applied posteriorly and superiorly, in and under the diaphragm
- Pressure is even and firm and more effective if the therapist uses their own body weight

Therapist position

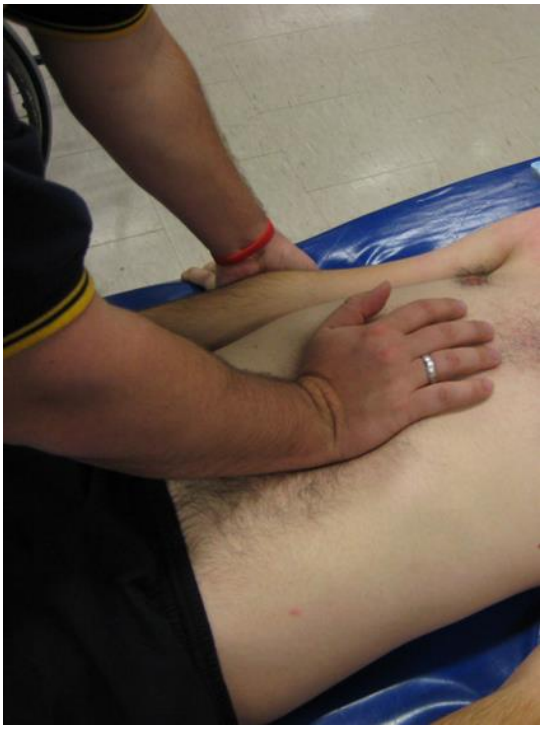
- A therapist may choose a lunge position, or kneel on the bed

Communication

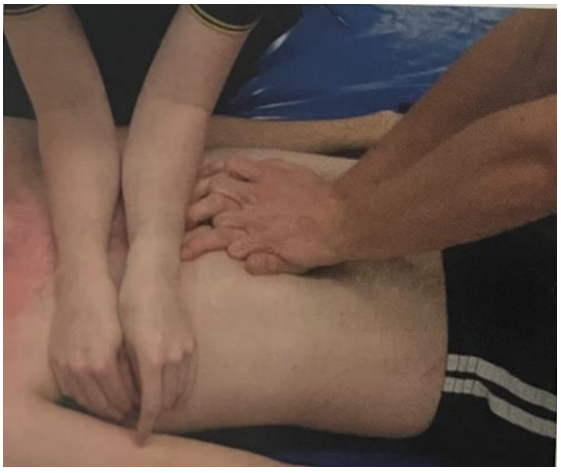
- Communication with the patient throughout dictates the success of the cough
- A “1, 2, 3, cough” command can be used or more simply the patient can take a couple of deep breaths and cough, while the therapist follows the patients lead

Single therapist hand position

1. Feel for the base of the sternum (xiphisternum) and the navel and place the heel of both hands midway between the two
2. One hand is inferior to the sternum to perform the cough while the other arm is across the anterior rib cage or two hands together



Two hand therapist position



Cough assist machine (In-Exsufflator)

The Cough Assist ^{TM} is used to allow expectoration of secretions when a cough is ineffective. This machine can be used in conjunction with a manual assisted cough to further improve a cough. The machine allows a higher flow and volume of air to be expelled quickly (FEV_1) to simulate a cough and improve effectiveness.

The machine delivers positive airway pressure followed by a quick change to negative pressure. The contraindications for its use are the same considered when using IPPB.

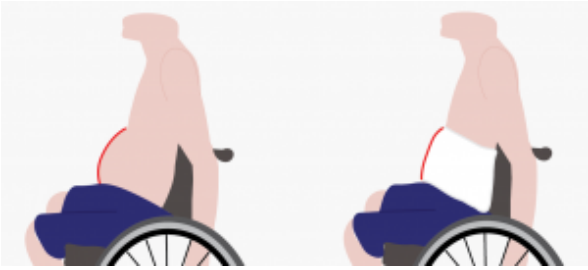
Other Management Strategies

Lung Volume Recruitment

Lung volume recruitment is a technique used to assist in taking a larger breath in or improving ventilation. It allows the user to achieve maximum insufflation capacity. This larger volume assists with expanding the lungs (vital capacity) and allowing a better cough (peak cough flow) than can be achieved without it. These breathing exercises can be done daily as a way of maintaining healthy lungs and assisting to clear any secretions that are present.

Abdominal binder

Wearing an abdominal binder has been shown to increase FVC, inspiratory pressures as well as manage shortness of breath and voice production in clients with higher levels of injury.



Inspiratory muscle training

This technique uses progressive resistance to improve inspiratory muscle strength and endurance. It has been shown to improve inspiratory muscle strength and endurance in individuals with SCI, which could then improve cough strength.

Signs of deterioration:

- drowsiness and lack of concentration
- slurring of speech
- decreased ability to co-operate with coughing etc
- altered respiratory rate
- decreased RFTs / FVC
- decreased air entry on auscultation
- increased production of sputum +/- colour change

Articles

1. Van den Berg ME, Castellote JM, de Pedro-Cuesta J, et al. Survival after spinal cord injury: a systematic review. J Neurotrauma 2010; 27: 1517–1528.
2. Waddimba AC, Jain NB, Stolzmann K, et al. Predictors of Cardiopulmonary Hospitalization in Chronic Spinal Cord Injury. Arch Phys Med Rehabil 2009; 90: 193–200
3. Berlowitz DJ, Wadsworth B, Ross J. Respiratory problems and management in people with spinal cord injury. Breathe 2016; 12: 328–340.

4. Jeong JH, Yoo WG. Effects of air stacking on pulmonary function and peak cough flow in patients with cervical spinal cord injury. J Phys Ther Sci. 2015 Jun;27(6):1951-2. doi: 10.1589/jpts.27.1951. Epub 2015 Jun 30. PMID: 26180355; PMCID: PMC4500018.
5. Wadsworth BM, Haines TP, Cornwell PL, Rodwell LT, Paratz JD. Abdominal binder improves lung volumes and voice in people with tetraplegic spinal cord injury. Arch Phys Med Rehabil. 2012 Dec;93(12):2189-97. doi: 10.1016/j.apmr.2012.06.010. Epub 2012 Jun 22. PMID: 22732370.
6. AB use in people with SCI review and meta analysis WADSWORTH 2008.pdf
7. AB improves lung vols and voice in people with tetraplegic SCI 2012.pdf
8. Karin Postma, Janneke A. Haisma, Maria T.E. Hopman, Michael P. Bergen, Henk J. Stam, Johannes B. Bussmann. Resistive inspiratory muscle training in people with spinal cord injury during inpatient rehabilitation: a randomized controlled trial. Physical Therapy (2014) volume 94 number 12 1709-1719
9. McDonald and Stiller Inspiratory muscle training is feasible and safe for patients with acute spinal cord injury. Journal of Spinal Cord Medicine vol 42 no 2 2019