Respiratory Management Following SCI Executive Summary

What Respiratory Problems Occur After Injury?

- **Difficulty clearing mucus**: The airways naturally produce mucus to trap debris. Problems with coughing or swallowing can cause the mucus to collect in the airways. This can encourage the growth of bacteria.
- **Pulmonary embolism:** When a blood clot forms, it can travel and cause a blockage within the lungs. This is referred to as pulmonary embolism.
- **Reduced lung capacity:** If the respiratory muscles are weak or paralyzed, not as much air can be breathed into or out of the lungs.
- **Respiratory failure:** When the lungs cannot efficiently exchange carbon dioxide for oxygen, oxygen levels may become too low or carbon dioxide levels may become too high.
- **Pneumonia:** When bacteria or viruses find their way into the lungs, an infection known as pneumonia can occur.

Respiratory system complications can be made worse by pre-existing medical conditions, history of smoking, advanced age and by therapeutic measures to manage the resuscitation phase of the injured patient.

How Common are Respiratory Problems After Spinal Cord Injury?

Respiratory problems affect 36-83% of SCI people in their acute phase or early phase of injury. Pneumonia, collapsed lung, and respiratory failure are the three most common respiratory problems. Respiratory complications continue to be one of the leading causes of morbidity and mortality in people with spinal cord injury (SCI), especially among cervical and higher thoracic injuries.

The complexity and the severity of respiratory problems after Spinal Cord Injury depend on which respiratory muscles are affected and at what level your spinal cord injury is. Complete paralysis of all muscles involved with respiration occurs when the lesion is above C3; this type of injury requires immediate and permanent ventilatory support in order to sustain life. When the injury is between C3 to C5 (innervation of the diaphragm), respiratory insufficiency occurs via respiratory muscle dysfunction.

SCI at most levels affects innervation of the abdominal muscles which severely compromises the ability to generate cough and clear respiratory secretions. Cough generation is accomplished by a large inspiratory volume followed by an expulsive expiration produced by the expiratory intercostals muscles (thoracic roots) and the abdominal muscles (T4-L1). Cough is important as a defense mechanism to prevent respiratory tract infections and atelectasis. The respiratory system has other important roles such as speaking and posture-related activities which can also be negatively impacted by the SCI, especially with higher lesions.

What are the Risk Factors for Respiratory Problems?

Many factors may contribute to how respiratory problems develop. These include:

- Completeness of the injury.
- Cause of the injury.

- Problems from tracheostomies or mechanical ventilation.
- A more severe injury.
- A larger lesion.
- A higher level of injury.
- Other fractures.
- A surgical tracheostomy instead of a percutaneous tracheostomy.
- No return of certain reflexes one day after the SCI.

What Management Options are There for Respiratory Problems?

Non-Pharmacological Options:

- There is evidence from a case series study that progressive ventilator free breathing (PFVB) protocol is more successful for weaning people with C3 and C4 spinal cord injuries than intermittent mandatory ventilation (IMV).
- Resistance and endurance training might improve resting and exercising respiratory function and should be considered in people who are candidates for ventilator weaning.
- The indications and criteria for tracheostomy tube removal have not been definitively established in SCI.
- For exercise training of the upper and lower limbs to improve respiratory function the training intensity must be relatively high (70-80% of maximum heart rate) performed three times per week for six weeks. Whereas ideal training regimes have not been identified.
- Respiratory muscle training improves respiratory muscle strength and endurance in people with SCI. Two RCTs and several case control and pre-post studies support RMT (IMT + EMT) as an intervention that will improve inspiratory and expiratory muscle strength, pulmonary function and functionality an exercise capacity. Five RCTs and several pre-post and case studies support Inspiratory Muscle Training (IMT) as an intervention that will improve inspiratory muscle strength and might decrease dyspnea and respiratory infections in some people with SCI. Three RCTs and several case control and pre-post studies support other protocols such as music and vocal intonation rehabilitation and other combinations of breathing training exercise as an effective way to improve pulmonary function, functionality, and quality of life in patients with SCI.
- Abdominal binding in tetraplegic individuals can improve respiratory function, and longer term use can continue to be effective.
- Chest percussion is a method where vibrations to the chest loosen mucus for easier removal. Vibrations can be made by clapping the chest. During manual assisted coughing, gentle pressure is applied to the chest during coughing. These techniques have been shown to reduce deaths related to respiratory problems. Chest wall vibration may improve pulmonary function while the vibration is applied (level 4 evidence based on 1 pre-post study) but long-term effects when the vibration is not in use has not been evaluated.
- Patients with SCI have a high prevalence of obstructive sleep apnea, and therapy may improve quality of life and other outcomes. Therefore, we recommend vigilance for suggestive signs and symptoms (e.g., snoring, obesity, witnessed apneas, daytime sleepiness) and further testing in patients with suggestive symptoms/signs (with overnight oximetry or polysomnography).

- Secretion removal techniques are common practice in people with spinal cord injury and yet there is predominantly only level 4 evidence to support the use of some airway clearance techniques to facilitate secretion removal in this population. There is level 2 evidence in support of mechanical insufflation/exsufflation coupled with manual chest therapy kinesitherapy techniques.
- There is no evidence that we know of that supports one airway clearance technique over another, and there are no criteria available to indicate when to implement the various airway clearance techniques.
- Cough effectiveness can be enhanced by a variety of methods including manual assistance by a caregiver, respiratory muscle training, glossopharyngeal breathing, spinal cord stimulation, and/or electrical stimulation triggered by the person with SCI.
- Phrenic nerve or diaphragmatic stimulation may be used as a long-term alternative to mechanical ventilation for people with injuries at C2 or above, and that people in phrenic paced conditions have lower mortality than their mechanically ventilated counterparts. Long-term partial or total independence from mechanical ventilation can generally be interpreted as a successful intervention with these devices.

Pharmacological Options:

- The use of Bronchodilators should be considered in people with tetraplegia who demonstrate an element of obstructive airway impairment. For instance, one RCT showed that salmeterol had beneficial effect on respiratory function in people with tetraplegia; bronchodilators may also have additional effects in strengthening breathing muscles such as the diaphragm. Caution should be used with ipratropium as it has been proposed that it may cause mucus in the airways to thicken, neutralizing its positive effects on breathing, though some studies have shown positive effects of ipratropium and metaproterenol on pulmonary function in people with tetraplegia.
- The effects of medications commonly used in the management of SCI, such as baclofen and oxybutynin, can decrease or block hyperresponsiveness to methacholine, but not histamine, in tetraplegia. There is 1 RCT that showed that high dose IV ambroxol after surgery increases blood oxygenation in cervical spinal cord injured patients with motor complete injuries.
- There is conflicting evidence that the short-term use of oxandrolone improves pulmonary function in people with tetraplegia.
- The use of Buspirone can be considered to improve cardiorespiratory and respiratory function in patients with high-level SCI during an exercise program employing FES - row training (FESRT).

Limitations of What We Know

Much of the SCI respiratory literature focuses on the acute care of the SCI patient. Given that long-term survival rates following SCI injury have increased in recent years, a greater understanding of the effects of chronic SCI on the respiratory system is necessary. This is largely because there have been relatively few well-designed studies that point to effective management strategies. Specific major concerns include an overall lack of RCTs; patient sample sizes are often small offering little statistical power; lack of appropriate control or placebo groups; and inadequate characterization of the SCI. In addition, most studies do not consider gender, time since injury, smoking history, and other respiratory complications. As such, the amount and quality of the literature can be considered modest at best and the ability to generalize is limited.

If we determined the most efficient and effective techniques that are comfortable and readily adhered to for people with SCI in order to facilitate airway clearance, it would improve their quality of life and decrease health care costs.

For More Information

SCIRE Professional: Pulmonary Complications during Acute SCI. Available from https://scireproject.com/evidence/acute-evidence/respiratory-management-during-acute-phase-of-spinal-cord-injury/pulmonary-complications-during-acute-sci/

Clinical practice guidelines addressing SCI:

1) The Paralyzed Veterans of America (PVA) Consortium for Spinal Cord Medicine—Respiratory management following spinal cord injury: a clinical practice guideline for health-care professionals (2005), and

2) Home mechanical ventilation: A Canadian Thoracic Society clinical practice guideline.