Acute Respiratory Management Following Spinal Cord Injury

The emphasis in respiratory acute care in people with spinal cord injury (SCI) is to maintain an open airway and diaphragm function while preventing respiratory failure, atelectasis, and pneumonia. This is a delicate balance for medical personnel as the presence of ventilation itself, despite assisting breathing, can directly lead to these pulmonary complications.

Typical Respiratory Outcomes/Issues by Level of Injury

- C1-C3 – Complete injury above C3 usually results in paralysis and denervation of all muscles required for inspiration and expiration. Life-long ventilation usually required. (Muscles for respiration innervated at this level: sternocleidomastoid and accessory muscles)
- C3-C5 – An injury from C3-C5 results in a variable inability to inspire and expire. Often ventilated. May be able to wean from ventilation in time, depending on other factors. (Muscles for respiration innervated at this level: diaphragm and pectoralis major)
- C6-C8 - Patients experience more difficulty with expiration than inspiration. May not experience respiratory failure, but often muscle fatigue. Often ventilated initially but can usually achieve independent breathing. (Muscles for respiration innervated at this level: scalenes accessory and pectoralis major)
- T1-T12 – Patients experience more difficulty with expiration than inspiration. Patients experience a reduced ability to cough with an injury at or above this level. (Muscles for respiration innervated at this level: external and internal intercostals, abdominal muscles)

Lung function tests that may be performed to evaluate lung capacity post-SCI include forced vital capacity (FVC), tidal volume (Vt), residual volume, expiratory reserve volume, inspiratory reserve volume, forced expiratory flow, and forced expiratory volume. Arterial Blood Gas (ABG) is often performed to monitor pCO_2 while adjusting ventilator settings, notably Vt.

These measures help determine the degree to which respiration is impaired, the degree of ventilation the patient may require, and overall patient outcomes. Measurement of maximum inspiratory and expiratory pressures (MIP, MEP) can be used to estimate strength of respiratory muscles and has been used to predict pneumonia risk (Raab et al. 2016).

Pulmonary Complications During Acute SCI

Respiratory complications occur in 36-83% of patients with acute SCI, the exact nature of which is dependent on the level of injury as this determines which respiratory muscles are affected due to loss of innervation (Warren et al. 2014).

Impaired respiratory muscle function leads to complications such as improper bronchial secretion clearance, pneumonia, atelectasis, septicemia, pulmonary embolism, and reduced forced vital and inspiratory capacity (IC) (Warren et al. 2014).

Overall, pneumonia is the most studied associated complication with a greater incidence in patients with a higher level of injury (Cotton et al. 2005; Fishburn et al. 1990), a more severe injury (Hassid et al. 2008; Huang & Ou 2014), larger lesions (Aarabi et al. 2012), additional fractures (Chen et al. 2013; Harrop et al. 2001), no return of deep tendon reflexes after one day (Lemons & Wagner 1994), and surgical vs. percutaneous tracheostomies (Romero-Ganuza et al. 2011). Raab et al. (2016) found that maximal inspiratory pressure (MIP) was significantly associated with pneumonia risk; those with MIP at 115% above their lesion had significantly fewer instances of pneumonia (Raab et al. 2016). In addition to pneumonia, atelectasis and respiratory failure are the most common pulmonary complications following acute SCI (Berlly & Shem 2007) which often require mechanical ventilation (MV) to manage (Galeiras Vázquez et al. 2013). To confound this problem, MV puts patients at an increased risk for ventilator-assisted pneumonia, demonstrating how these complications can be difficult to control. Patients with ventilator-assisted pneumonia have an extended hospital stay and a death rate of 20-30% (Call et al. 2011; Cook 2000).

There is conflicting evidence regarding tracheostomies and their role in the development of respiratory complications. Some studies have found that patients who had tracheostomies experienced reduced respiratory complications compared to patients who did not have a tracheostomy (Leelapattana et al. 2012), whereas other studies reported the opposite (Harrop et al. 2004; Kornblith et al. 2014).

Pulmonary complications cause a significant burden to the individual and health care system, as it increases time on ventilation, hospital stay, and costs (Aarabi et al. 2012; Chen et al. 2013; Kornblith et al. 2014; Winslow et al. 2002). Furthermore, if complications cannot be managed initially, they may accumulate and put a patient at risk for more respiratory problems. For example, Huang and Ou (2014) found that the presence of respiratory failure led to a higher likelihood of developing pneumonia. Therefore, it is important that prophylactic measures be taken to prevent pulmonary complications, and that they are managed intensely. It has been suggested that the key to their prevention is intense secretion management (Claxton et al. 1998). Large volumes of mucus, or mucus staying inside the lung for extensive periods of time, encourage the growth of bacteria and subsequent development of pneumonia.

Overall, the current literature indicates that people with SCI should be screened and monitored for respiratory complications in the acute phase of SCI given their frequency as well as multifaceted origins.

Key Points

Intubation can reduce arterial oxygen partial pressure ratios in people with acute SCI.

Tracheostomies can reduce the number of pulmonary complications in people with acute SCI compared to those not receiving this procedure, and they may result in reduced FVC and lower gas exchange compared to extubation.

Tracheostomies are associated with an increase in the number of days people with acute SCI spend on ventilators. Between 21% and 77% of patients with cervical SCI require a tracheostomy, with the variability of these numbers related to the influence of at least 16 other factors (e.g., severity of the injury, presence of other injuries, admission Glasgow Coma Scale score, age, etc.) (Branco et al. 2011; Como et al. 2005).

Percutaneous tracheostomies may reduce rates of pneumonia when compared to surgical tracheostomies in people with acute SCI.

Early tracheostomies may result in fewer intensive care unit (ICU) days and ventilation days; however, they may not impact in-hospital mortality compared to late tracheostomies. The evidence is inconsistent whether early tracheostomies reduce medical complications compared to late tracheostomies.

Weaning from MV is more successful in patients who have not had a tracheostomy, and rates of decannulation and extubation are higher in patients with lower-level injuries during the acute phase post SCI.

For MV weaning, progressive ventilator-free breathing (PVFB) may be more successful than intermittent mandatory ventilation / invasive mechanical ventilation (IMV), and using higher ventilator tidal volumes may speed up the weaning process compared to lower ventilator tidal volumes during the acute phase post SCI.

Diaphragmatic pacing in combination with MV can increase survival rates post SCI.

Endotracheal invasive ventilation (EIV) can lower partial pressure of carbon dioxide in people with acute SCI.

Mechanical insufflation/exsufflation coupled with manual respiratory kinesitherapy may be effective for bronchial clearance during the acute phase post SCI.

Inspiratory and expiratory muscle training may improve respiratory muscle function during the acute phase post SCI. Length of stay (LOS) in intensive care may be reduced by extubation in combination with intensive physiotherapy, may lead to fewer procedures and ventilator days, shorter hospital LOS, and improved respiratory and patient discharge status, in the acute phase post SCI.

Bronchodilator therapy with medications (i.e., salbutamol or ambroxol), may be effective treatments for improving pulmonary function and reducing pulmonary complications during the acute phase post SCI.

Caution regarding research in acute respiratory SCI

Fewer than ten percent of studies to date are RCTs; the majority of studies are retrospective and examine which factors on admission to acute care are associated with certain interventions and outcomes. This means that recommendations have not necessarily been established by the high standard recognized in experimental research. More prospective/match-controlled trials, or retrospective case-control reviews are required with larger samples to deliver better information regarding acute respiratory management in SCI.