Respiratory Complications

Respiratory complications are a leading cause of death acutely post-injury. This is due to paralysis of respiratory muscles, relative bronchoconstriction, excess secretions, ventilation/perfusion mismatch.

Atelectasis is the most common respiratory complication in patients with spinal cord injury and may lead to pneumonia, pleural effusion, and empyema.

Respiratory infections should be treated promptly with assisted coughing, physiotherapy, and antibiotics.

Pulmonary embolism, sleep apnea and respiratory failure are also potential complications that clinicians looking after patients with SCI, should be aware of.

All patients with a spinal cord injury above L1 will have some form of lung dysfunction. The higher the level of injury the more severe the lung dysfunction will be.

As vital capacity is directly related to respiratory muscle strength, the higher the spinal cord injury the greater the decrease in vital capacity. A downward trend in vital capacity should be fully investigated as may lead to respiratory insufficiency.

Patients with tetraplegia with lesions at C5 and above have improved ventilation in supine position. Vital capacity is decreased in the sitting position due to increased effects of gravity on the abdominal contents, which leads to increased residual lung volume.

Patients with tetraplegia should be encouraged to perform daily routine inspiratory resistive training as this has been shown to improve strength and endurance of weak diaphragms and increase lung function.

Definitions

Atelectasis

Atelectasis is the most common respiratory complication of spinal cord injury. It refers to a collapsed lung segment due to retained secretions/decreased ventilation.

Bilevel Positive Airway Pressure (BiPAP)

Bilevel Positive Airway Pressure delivers a preset inspiratory positive airway pressure (IPAP) followed by a preset expiratory positive airway pressure (EPAP).
Continuous Positive Airway Pressure (CPAP)
Continuous Positive Airway Pressure is the use of continuous positive pressure to maintain a continuous level of positive airway pressure.

Forced Expiratory Volume in 1 second (FEV1)
The FEV1 is the maximum volume of air that can be forcefully exhaled during one second.

Peak Expiratory Flow (PEF)
The Peak Expiratory Flow is the maximum flow (speed of expiration) generated during maximum forceful expiration after a full inspiration.

Vital Capacity (VC)
Vital capacity is the maximum volume of air that can be expelled after a maximum inspiration.

Pathophysiology
Respiratory dysfunction resulting from cervical spinal cord injury depends on the level of injury and the extent of innervation. The higher level lesions result in denervation of progressively more of the expiratory and inspiratory muscles as illustrated in the image shown. The compliance of the lungs diminishes with increasing time after spinal cord injury.

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. The primary goal of ventilatory support is to ensure arterial blood gas homeostasis.

When the injury is between C3 to C5 (innervation of the diaphragm), respiratory insufficiency occurs via respiratory muscle dysfunction. Partial or fully denervated expiratory muscles in those with spinal cord injury will diminish exercise ventilation and ventilatory reserve.

Spinal cord injury at most levels affects innervation of the abdominal muscles (see image), severely compromising the ability to generate cough and clear respiratory secretions. Cough is important as a defence 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 spinal cord injury, especially with higher lesions. Patients who are unable to reliably clear respiratory secretions may require assisted coughs. Patients who are very productive and unable to manage secretions effectively may require tracheostomy.

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### Signs and symptoms

Atelactasis may present with:

- Change in respiratory rate
- Shortness of breath
- Increased heart rate
- Increased anxiety
- Increased volume or thickness of secretions
- Decrease in Vital Capacity (VC)
- Decrease in Peak Expiratory Flow (PEF)
- Decreased oxygen saturation
- Elevated temperature

Deep venous thrombosis/pulmonary embolus may present with:

- Swelling, redness, pain in the leg (if sensation preserved)
- Shortness of breath, chest pain
- Unusual symptoms such as Autonomic Dysreflexia (AD), unexplained fever, or altered mental state
- Increased risk during period of illness, pressure sore, bedrest

Sleep apnea may present with:

- Snoring
• Witnessed apneas
• Daytime Sleepiness
• Obesity
• Nocturnal choking

Risk Factors

Risk factors for respiratory complications in patients with spinal cord injury:

• Higher level of complete neurological impairment
• Age >50 years
• Recent hospital admission
• Smoking
• Chronic lung disease (e.g., Chronic Obstructive Pulmonary Disease [COPD])
• Severe postural deformity
• Obesity
• Decrease in pulmonary function tests

Management and recommendations

Atelectasis needs to be recognised and treated to avoid further complications such as pneumonia, pleural effusion, and empyema.

Atelectasis is most commonly found in the left lower lobe so auscultation should be done either sitting up on lying on right side. Monitoring vital capacity is one of the best ways to detect early problems.

Treatment includes both lung expansion and mobilisation and clearing for secretions.

This can be accomplished using different methods:

• Assisted coughing (using abdominal thrust or compression)
• Use of insufflator/exsufflator
• Chest physiotherapy
• Placing patient in supine position (increases FEV1 and vital capacity)
• Bronchodilator (patients with spinal cord injury often have hyperactive airway due to unopposed cholinergic tone)
• Abdominal binder/splinting (helps increase FVC/reduce residual lung volume in sitting position by elevating abdominal contents, allowing diaphragms to move effectively)
• Continuous Positive Airway Pressure (CPAP) or Bilevel Positive Airway Pressure (BPAP)
• Suctioning
• Increasing tidal volume on ventilator

Any signs or symptoms of pneumonia should be evaluated promptly with a chest x-ray and treated with assisted coughing, physiotherapy, and antibiotics +/- Nebulisers (normal saline and/or salbutamol). Patients with thick and/or increased secretions may benefit from mucolytic agents such as oral carbocisteine, short term N-Acetylcysteine nebuliser (through air, with immediate chest physio afterwards) or hypertonic saline nebuliser. Sputum samples may grow pseudomonas, this is a common coloniser of the upper respiratory tract, especially following antibiotics; clinical correlation is advised.
Signs or symptoms of pulmonary embolism should be investigated promptly with CT-PA and if clinically suspected patient should be started on a therapeutic dose of low molecular weight heparin until fully investigated. If venous thrombo-embolism is found the patient will need to be on anticoagulation for 6-9 months and then risk factors need to be reviewed.

Consider sleep study or nocturnal oximetry test to check for sleep apnea if there are signs and symptoms of sleep apnea. Continuous Positive Airway Pressure (CPAP) can be successful in treating sleep apnea in patients with SCI.

**Follow-up**

- Closely monitor patients with an increased number of respiratory infections and/or hospital admissions for respiratory problems or refer to SCIC
- Encourage patients with tetraplegia to perform routine daily inspiratory resistive training, which has been shown to improve strength and endurance of weak diaphragm and increase lung function
- Pulmonary Function Tests when required and compared to a baseline
- Smoking cessation
- Yearly influenza vaccination
- Pneumococcal vaccination, repeat once if first dose before age 65
- Encourage exercise (increases lung capacity)

**Respiratory failure**

Occurs in about 1 in 5 patients within the first week of spinal cord injury

Can also occur later due to contributing factors:

- Post-traumatic syringomyelia (fluid-filled cavity in spinal cord)
- Cervical spinal stenosis with compression
- Obesity
- Progressive scoliosis/kyphosis
- Atelectasis/pneumonia
- Sedative medication
- Loss of diaphragm motor fibres

Signs of impending respiratory failure:

- Hypoxia with increase in respiratory rate
- Decrease in vital capacity to less than 15cc/kg ideal body weight
- Decrease negative inspiratory force to less than 20cm H2O
- Hypercarbia
- Fatigue
- Tachycardia

Treatment:

- Recognise early
- Requires intubation and mechanical ventilation
- If intubation necessary for more than 5 days consider tracheostomy (for more information please refer to Respiratory Information for Spinal Cord Injury (RISCI))
• Patient will then need to be weaned off ventilation when appropriate (see RISCI weaning guidelines for more details)

References


