

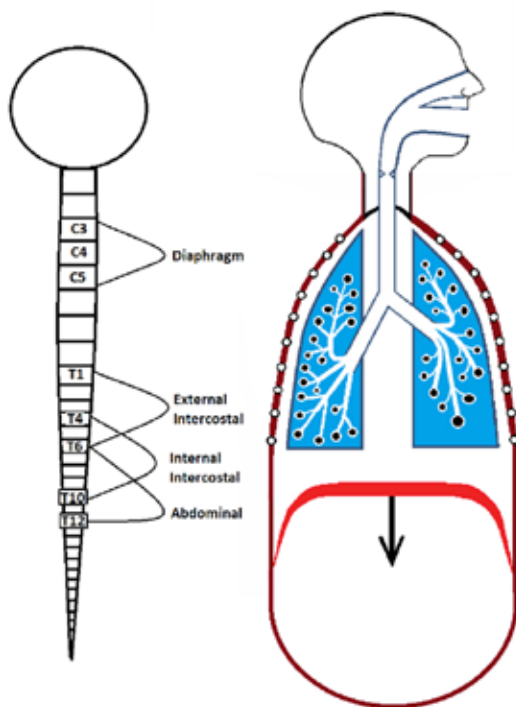
RESPIRATORY DYSFUNCTION AND MANAGEMENT



INTRODUCTION

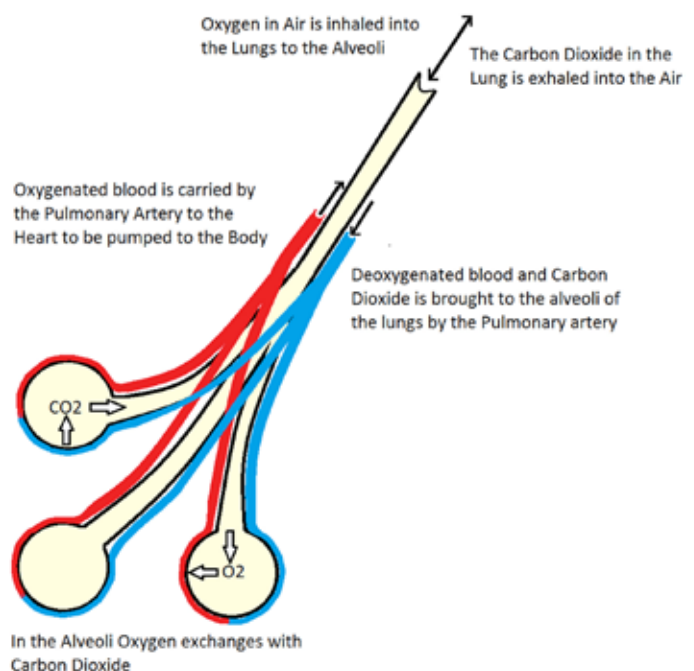
Diseases of the respiratory system have been the leading cause of death in persons with spinal cord injury (SCI) from 1973 to 2019 (National SCI Statistical Center, 2019 Annual Report). Breathing is both the physical and chemical exchange that moves air in and out of the lungs. In the process, several key functions are affected:

1. Breathing enhances oxygen and carbon dioxide exchange to maintain life
2. Cough is enabled to propel air and secretions out of the lungs
3. Vocalization occurs as air passes over the vocal cords
4. Smell and taste is enhanced as air passes over the nasal epithelium
5. Acid-Base balance is controlled with the elimination of carbon dioxide



The neurological level and completeness of SCI will help determine whether there is impaired or absent innervation of the breathing muscles, which can affect inspiration and expiration. In addition, breathing can be passive or active. Passive involuntary breathing is the process in which air is drawn into the lungs by the negative pressure generated by diaphragm muscle contraction and pushed out of the lungs by positive pressure created during elastic recoil of the chest wall. Active breathing can be produced by voluntary diaphragm, intercostal and abdominal muscle contraction.

The brain controls the rate and depth of breathing. Signals from the brain travel down the right and left phrenic nerves that innervate the diaphragm muscle (C3-C5). Signals from the brain also innervate the external intercostal muscles (T1-T6) that are important for active inspiration and the internal intercostal muscles (T4-T10) that are important for active expiration. And finally, the contraction of abdominal musculature (T6-12) produces forceful expiration and therefore cough.



The diaphragm is the major muscle for quiet restful breathing. When the diaphragm contracts, it moves downward, and spreads out. This movement increases intra-abdominal pressure and decreases intrathoracic pressure. The decreased intrathoracic pressure around the lungs, causes the alveolar pressure to drop and air flows into the lungs. In addition, decreased intrathoracic pressure also enhances venous blood flow to the heart that will enhance delivery of carbon dioxide to the alveoli. The air flowing into the lungs is rich in oxygen and blood flowing to the alveoli is rich in carbon dioxide. Arteriole blood vessels absorb the oxygen and the venous blood vessels expel carbon dioxide into the alveoli. When the diaphragm relaxes, intrathoracic pressure increases, alveoli collapse and carbon dioxide is forced out of the lungs.

Continued management of ventilator needs for those discharged to home and for those that require full-time or part-time mechanical ventilation is coordinated by a multidisciplinary team of in-patient and outpatient providers to ensure all needs are met. Caregivers are provided detailed education and training on the equipment and techniques necessary to maintain a safe home environment. This section provides an overview on some of the equipment and techniques available for respiratory management when discharged from an acute care or rehabilitation facility. This is not an endorsement of products pictured in this chapter.

Equipment That is Medically Necessary for Those That Require Breathing Assistance and/or Assistance with Secretion Clearance

Breathing Assistance

- Mechanical ventilator (recommended one for bedside and one for wheelchair)
- Wheelchairs can be fit with a ventilator trays or racks for easier maneuverability
- Gel-Cell batteries (recommended one for bedside and one for wheelchair)
- Battery charger
- Vent circuits with necessary adapters
- Manual ventilation bag with mask

Humidification

- Heated humidifier with water chamber
- Sterile water for humidification
- Heat-Moisture Exchanger (used to provide humidification when not using heated humidification)

Optional Equipment for Breathing Assistance

- Non-invasive ventilation with mask interface
- Diaphragm Pacing
Surgically implanted device for patients that have intact phrenic nerves
Provides natural, physiologic breathing

Secretion Clearance

- Suction machines (Electric and battery powered)
- Suction catheters appropriate for size of tracheostomy tube
- Saline for suctioning

Airway Management

- Tracheostomy tubes
If cuffed tube is used, syringe for cuff inflation/deflation
- Tracheostomy tube holders
- Tracheostomy cleaning kits
- Lubricant
- Dressing supplies
- Travel/Emergency bag
Current size tracheostomy tube
One size smaller tracheostomy tube
Syringe for cuff inflation/deflation
Tracheostomy tube holders
Lubricant
Manual ventilation bag with mask
Ventilator circuit with HME
Suction catheters
Saline for suctioning
Emergency contact information

Comfort and Mobility

- Adjustable hospital bed
- Wheelchair with tray for battery

RESPIRATORY DYSFUNCTION EQUIPMENT



Breathing Assistance / Ventilator



Wheelchairs Ventilator Trays or Racks
<https://quantumrehab.eu/accessories-eu/trilogy-vent-tray>



Non-invasive Ventilation with Mask Interface



Suction Machines

www.drivemedical.com/us/en/Products/Respiratory/Suction-Therapy-Accessories/c/SuctionTherapyAndAccessories



Diaphragm Pacing



Mechanical Cough Assist Device with Appropriate Interface



Equipment/Techniques That May be Medically Necessary

- Oxygen, if indicated
- Finger pulse oximeter device to monitor vitals and oxygen saturation
- Incentive spirometer
- Pneumobelt for assistance in exhalation
- Speaking valve with necessary adapters to facilitate speech
- Air compressor for aerosolizing medication with necessary adapters
- Mechanical cough assist device with appropriate interface
- High frequency chest wall oscillation (HFCWO)
- Intrapulmonary percussive ventilation (IPV)
- Chest physiotherapy (CPT)
- Manually assisted cough techniques
- Combination Device (Metaneb System - Lung expansion, secretion clearance, aerosol delivery)

References:

1. National SCI Statistical Center, 2019 Annual Statistical Report for the SpinalCord Injury Model Systems. University of Alabama at Birmingham: Birmingham, Alabama.
2. Schilero GJ, Bauman WA, Radulovic M. Traumatic Spinal Cord Injury: Pulmonary Physiologic Principles and Management. Clin Chest Med. 2018 Jun;39(2):411-425. doi: 10.1016/j.ccm.2018.02.002.
3. DiMarco AF, Altose MD, Cropp A, Durand D. Activation of the inspiratory intercostal muscles by electrical

stimulation of the spinal cord. Am Rev Respir Dis 136:1385-1390, 1987. PMID: 3688644.

4. DiMarco AF, Romaniuk JR, Kowalski KE, Supinski GS. Efficacy of combined inspiratory intercostal and expiratory muscle pacing to maintain artificial ventilation. Am J Respir Crit Care Med 156:122-126, 1997. PMID: 9230735.

WEBSITES

Breathing Assistance

www.usa.philips.com

www.vyaire.com

Wheelchairs Ventilator Trays or Racks

<https://quantumrehab.eu/product/trilogy-vent-tray>

Non-invasive Ventilation with Mask Interface

www.usa.philips.com

www.resmed.com

Suction Machines

www.drivemedical.com

www.devilbisshealthcare.com

Mechanical Cough Assist Device with Appropriate Interface

www.usa.philips.com

www.respironics.com

Diaphragm Pacing

www.synapsebiomedical.com

High Frequency Chest Wall Oscillation

www.hillrom.com

www.afflovest.com

Combination Device

www.respiratorycare.hill-rom.com



AffloVest by International Biophysics Corporation



Combination Device

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