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Regional Spinal Cord Injury Center of the Delaware Valley  
NIDRR-designated

# *Spinal Cord Injury Manual*

A publication of the  
Regional Spinal Cord Injury Center  
of the Delaware Valley

The Regional Spinal Cord Injury Center of the Delaware Valley provides a comprehensive program of patient care, community education, and research. It is a federally designated program of Thomas Jefferson University and its affiliated institutions of Thomas Jefferson University Hospital and Magee Rehabilitation Hospital.



# Spinal Cord Injury Patient-Family Teaching Manual

**A Publication of the  
Regional Spinal Cord Injury Center  
of the Delaware Valley**

Researched and prepared by the clinical  
personnel of Thomas Jefferson University  
Hospital and Magee Rehabilitation Hospital

Available online at:

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## Dedication

The Handbook Committee of the RSCICDV gratefully acknowledges the assistance and dedication of all who contributed to this manual, and all the others who worked so hard to make this Handbook a reality.

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This publication is supported in part by Thomas Jefferson University, a grant received from the National Institute on Disability and Rehabilitation Research (NIDRR), Office of Special Education and Rehabilitative Services (OSERS), U.S. Department of Education, Washington, D.C. and by the Geoffrey Lance Foundation.



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# Respiratory Dependent

## Introduction

One of the most important aspects of spinal cord injury care is respiratory management. The previous chapter deals with the effect spinal cord injury has on your ability to breathe while this chapter deals with the management of individuals who are dependent on a ventilator to breathe. This dependency may be temporary or permanent, depending on your level of injury. Please review the previous chapter prior to reading this one.

## Artificial Airways

The first step in trying to maintain normal respiratory function is to establish an airway. Spinal cord injury does not affect your airway. However, in order to re-establish respiratory function, an artificial airway is needed to work with the ventilator. At first, this is done by using an endotracheal tube (ET tube). This tube is inserted through your nose or mouth and into your trachea. The ET tube has a balloon, which is inflated. This helps to prevent air from leaking into your nose or mouth. The ET tube is held in place with tape to the person's cheeks. The ET tube provides a passage through which either a manual resuscitator or a ventilator can deliver air.

The ET tube is considered temporary. If the person needs ventilatory assistance for a long time, a tracheostomy may be performed. Tracheostomy tubes are more comfortable for people and provide options for communication that an ET tube cannot. A tracheostomy is a sterile procedure that is done in the operating room. An incision is made into the person's trachea and a shorter tube, similar to the ET tube, is inserted. The tracheostomy tube is held in place with ties that look similar to a shoestring. Many companies make tracheostomy tubes, each with pluses and minuses. Generally, the first tracheostomy tube that is placed is called a *non-fenestrated, cuffed* tube. This tube does not allow the individual to speak, and the cuff helps the individual to protect his or her airway from food, as well as helps to keep the air from leaking into the nose and mouth. The tubes can be adapted to meet the individual's needs. A tracheostomy tube can be replaced or changed as your needs change.

## Mechanical Ventilation

The most important step of maintaining life is to provide the person with the air that he or she is unable to inhale. Using a mechanical ventilator does this. There are many brands on the market, all of them providing similar functions. The ventilators



that are currently used are called *volume cycle* ventilators. This means that the ventilator will deliver a set amount of air to the person. The volume that is given to any one person is individualized, and is based on many factors, including the person's size, age and medical status.

### **About Mechanical Ventilators**

Volume cycled ventilators are set to deliver a certain number of breaths to the person. This number of breaths (or respiratory rate) is similar to the rate that the individual would breathe on his or her own. These ventilators also have a sensitivity control, which can be adjusted to pick up the individual's respiratory effort. If the individual initiates a breath, the ventilator will cycle to deliver the preset volume of air.

The ventilator can also deliver added oxygen. The amount of oxygen delivered is determined by the amount of oxygen present in the person's blood. This is read from a test called an Arterial Blood Gas or ABG. Added oxygen may be needed for many medical reasons.

Ventilators also have a built in alarm system. There is a high-pressure alarm, which is set off whenever there is interference with the air being delivered and a low-pressure alarm that is set off whenever the ventilator is disconnected from the individual.

### **Portable Ventilators**

The ventilator that is used in the intensive care unit and in the acute care setting may be different in size and brand from the one that is used when you go into a rehabilitation setting. Since the main purpose of rehabilitation is to get the individual out of bed and engaged in activities, a large size ventilator is not practical. Once the person is transferred to the rehabilitation component of the program, he or she is transferred to a portable ventilator. Again, there are many different brands. However, they all function in a similar manner and are able to provide the same functions as the larger ventilators.

One of the main differences between a portable ventilator and a non-portable ventilator is the way that the ventilator is powered. Portable ventilators have the ability to have power provided in a variety of ways: through the wall outlet, an internal battery or an external battery. This ability provides the

individual with the ability to be mobile and not be dependent on a wall outlet for the ventilator to work.

Portable ventilators are electrically powered and can be operated in the following ways:

Portable Ventilator



Courtesy Respironics

- **110 VAC (House Current):** The ventilator can operate indefinitely when plugged into an everyday electric outlet.
- **External 12 VDC Deep Cycling Battery:** When used outside of the home or away from house current, the ventilator can operate up to 24 to 36 hours on a fully charged battery. Using a battery charger can recharge this battery or it can recharge when it is connected to the ventilator and the ventilator is plugged into the wall. Adapters are also available for plugging into an automobile cigarette lighter while in transit.
- **Internal Battery:** Ventilators are equipped with an internal battery that will provide electric power for one or more hours when no other power source is available. The internal battery is automatically recharged when the ventilator is connected to house current. An alternate power source should be found as soon as possible when this battery is in use.

Ventilators are equipped with the ability to automatically switch from one power source to another. Indicator lights show which power source is in use.

### Operation of the Ventilator

The control knobs, switches and buttons on portable ventilators are different in appearance, shape and size from hospital ventilators, but they control the same functions of the machine.

All portable ventilators are able to deliver tidal volumes of 100 cc to 3,000 cc. The respiratory rates that can be set are from two breaths per minute to 60 breaths per minute. The mode, or way that the ventilator delivers breaths, can be set in either a assist-control rate or SIMV (synchronized intermittent mandatory ventilation).

The portable ventilator is able to deliver phases with adjustable volumes, rates and frequencies. Oxygen can be delivered also through the portable ventilator with some adaptations to the setup.

## **Alarms**

Most portable ventilators that are used today have the ability to be hooked up to a remote alarm system. This system allows the ventilator alarms to be heard outside of the individual's room into the hallway. As a safety feature, the ventilator should be connected to the remote alarm whenever you are in your room by yourself. This alarm system will alert nursing personnel to the fact that something may be wrong with your ventilator

## **Weaning from the Ventilator**

Weaning from the ventilator is a gradual and systematic procedure that may be used to allow you to breathe independent from the ventilator. Not all individuals who are on a ventilator will be able to be weaned; however, every attempt is usually made to allow individuals the opportunity to wean, if only for a few minutes. The objective is to be off of the ventilator for as long as safely possible.

Since this is often a difficult and challenging process, the psychological preparation is extremely important and must begin before the actual weaning attempt. It is important to keep in mind that this process can be frustrating and may take a long time to complete. Some individuals may never complete the process, while others seem to come off the ventilator quickly with few problems. There are many factors that can affect this process, so it is important not to compare yourself to other individuals.

Before the weaning process begins, there are certain criteria that the individual needs to meet. These criteria include a clear chest x-ray and medical stability for several weeks to months. The weaning process maybe started shortly after injury or may be a long-term goal.

During the process, blood gases may be checked at a regular basis. Your oxygen saturation level maybe monitored throughout the process using a pulse oximeter. Your respiratory rate and effort are also monitored to help prevent your respiratory muscles from tiring out or fatiguing. Signs that you may be tiring your respiratory muscles include a fast respiratory rate with difficulty breathing. Each person's weaning schedule is individualized.

As your medical stability progresses, it is possible that the weaning procedure will include a gradual decrease in the size of the tracheostomy tube and a change in the type of tracheostomy tube that you are using. If you wean completely

from the ventilator, often the next step in the process is to wean you from the tracheostomy tube. Again, this is an individualized process, so it is important not to compare your progress with someone else's.

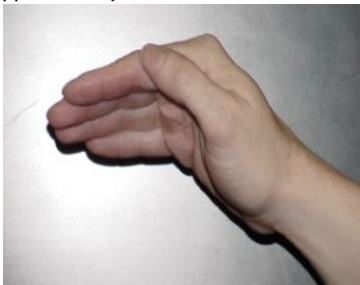
### Monitoring the Weaning Process

Ventilatory parameters are a group of test measurements or tests that can be done either by the respiratory therapist or the nurse. These studies are done utilizing a hand held device called a *respirometer*. This device is used when the person is off the ventilator, it tells the team how well you are doing in breathing on your own. Respiratory parameters are usually done before and after a weaning session, and are done to determine if you are ready to start weaning. Parameters include vital capacity, tidal volume and negative inspiratory force.

### Postural Drainage and Chest Physical Therapy

Postural drainage and chest physical therapy, along with respiratory treatments and coughing, are helpful in keeping secretions moving and lungs and airways clear. Postural drainage works by placing the person in several positions, which will encourage drainage of secretions so they can be easily removed from the lungs. If you are on a ventilator, the positions that you can use are limited.

*Cupped Hand for Chest PT*



Postural drainage is often accompanied by chest physical therapy (chest percussion and vibration). Chest physical therapy is used to help loosen bronchial secretions. Cupping your hands and clapping them against the chest wall does chest percussion. Chest percussion should not be done any more than one to two minutes on any area. You should avoid doing chest percussion on bony areas and female breast tissue.

*Chest Compression and Clapping - Target Areas for the Back*



This motion traps the air between the hand and the chest wall. The sudden compression of air produces an energy wave that is transmitted through the chest wall, producing an energy wave that is transmitted through the chest wall tissue to the lung tissue. The energy wave will loosen mucus plugs and allow better movement of secretions by gravity and coughing techniques.

Chest vibration is also a means of mobilizing secretions to keep the airways clear. Vibration is a very effective means of moving secretions in major airways. Placing the hands flat on the chest wall, produce a very fast vibrating motion with the arms extended, while gently compressing the chest wall. This process is the technique of chest vibration. This procedure should be

performed no longer than one to two minutes on any one area. You should avoid bony areas and breast tissue.

(See Respiratory Chapter, Page 5-5.)

## Assistive Cough

*Quad Assisted Cough*



Another way to help keep the airways clear is the quad assist cough. The quad assist cough is a way of working with the person who has a minimal cough. This procedure makes it easier to cough up the secretions that have accumulated in the lungs. Quad assisted coughing is done by placing the heel of the hand on the person's diaphragm. The person is asked to take a deep breath. The assistant pushes forcefully on the diaphragm in an upward and inward motion toward the shoulders. This motion helps to provide forced exhalation and the movement of secretions. The procedure is repeated until the person has cleared his or her airway or is tired. If the person is tired, and all secretions are not removed, then suctioning may be necessary.

## Manual Resuscitator

*Manual resuscitator*



A manual resuscitator, or Ambu<sup>®</sup> bag, looks like a balloon and is hand operated. A manual resuscitator delivers air to the individual by having someone gently squeeze the bag after attaching it to the tracheostomy. An Ambu<sup>®</sup> bag should be kept with the person **at all times**. All family members and attendants must know how to use the manual resuscitator before the person can leave the nursing unit without a nurse.

## Electrophrenic Pacing

An electrophrenic pacer is an electronic device that provides electrical stimulation to the phrenic nerve, stimulating the diaphragm and allowing the individual to inhale. In order to be a candidate for an electrophrenic pacer, the individual's level of spinal cord injury must be at C1 or C2.

The electrophrenic pacer was implanted successfully for the first time in 1970 to completely wean an individual with tetraplegia from a ventilator. In order to determine if an individual is a candidate for use of an electrophrenic pacer, the

first step is to make sure that the phrenic nerve is intact and capable of being stimulated. The second step is to make sure that the phrenic nerve responds to the stimulation. This is done by stimulating the phrenic nerve with an EMG (electromyography) needle. While the phrenic nerve is being stimulated, the diaphragm is observed on a special type of x-ray called *fluoroscopy* to see if the diaphragm moves enough to take in a breath. If this is successful, several other tests may be ordered to determine if this type of ventilatory system will work for you. These other tests may include the following:

- **Arterial Blood Gas:** This test helps to determine how medically stable you are.
- **Bronchoscopy:** This test helps to determine if your airway is clear.
- **Chest X-ray:** Shows that your chest wall is stable.

There are other things, which need to be considered before determining if you are a candidate for electrophrenic pacing. These factors are:

- You are at least six to twelve months after injury.
- You have someone who is able to monitor the electrophrenic pacing and can help to support breathing using the Ambu<sup>®</sup> bag or ventilator.
- You have a physician who will follow you in the community.

Why should you think about using an electrophrenic nerve pacer? Often times, people who use this system are able to maintain a smaller tracheal opening. This causes less damage to the trachea. Secondly, this equipment is much less bulky than a ventilator; and third, there are no tubes going from the trachea to the machine.

## Surgery

Once it has been determined that you are a candidate for phrenic nerve pacing, the surgery will be scheduled. In the operating room, an incision will be made to locate the nerve, and an electrode will be placed carefully around it. This electrode is used to stimulate the nerve and is called the *stimulating electrode*. A wire is placed from the stimulating electrode to the abdominal wall, where it is connected to the radio receiver. The radio receiver is implanted under the skin. There is a battery-operated transmitter, which is placed on a tray on your wheelchair.

After the surgery is completed, the system is carefully tested. This will be done daily until you are ready to begin functional pacing. Functional pacing usually begins about 12 to 15 days after your surgery. Gradually, the time on the pacers will be increased, and your time on the ventilator will be decreased. It can take you from six to eight months to achieve your maximum pacing time.

### **Limitations on Electrophrenic Pacing**

The implanted receiver will function for approximately two years before it needs to be replaced. Usually, there is a warning prior to the system failing; however, failure can happen suddenly. For this reason, you should be near an Ambu<sup>®</sup> bag or ventilator at all times. Also, it is recommended that you have a sleep alarm system (such as an apnea monitor) or use the ventilator for sleeping so that a “fail safe” system for breathing exists at all times.

### **Medications**

There are several different medications that you may be taking to increase your respiratory function. These medications can be taken either by mouth or by inhalation. The medications that you are on will vary depending on your medical stability. The types of medication that you may be taking include: bronchodilators (opens the bronchi), mucolytics (thin the secretions) or bronchial antispasmodics (relax the bronchi). Again, remember that everyone is different, and the medications that you are on may be different than other individuals with spinal cord injuries.

## Medications for Respiratory Program

Medications	What	Use	Possible Side Effects	Tips
<b>Albuterol</b> ®	Bronchodilator	Used to open the airways.	<ul style="list-style-type: none"> <li>• Fast pulse</li> <li>• Headache</li> <li>• Rise in blood pressure</li> <li>• Anxiety</li> <li>• Restlessness</li> </ul>	<ul style="list-style-type: none"> <li>• Make sure that you take only the amount the doctor prescribes.</li> <li>• Make sure that you drink plenty of fluids.</li> </ul>
<b>Atrovent</b> ®	Bronchodialator, Anticholinergic	Used to open the airway and shrink swollen membranes.	<ul style="list-style-type: none"> <li>• Fast pulse</li> <li>• Dizziness</li> <li>• Headache</li> <li>• Blurred vision</li> <li>• Nausea</li> <li>• Vomiting</li> <li>• Cough</li> <li>• Upset stomach</li> </ul>	<ul style="list-style-type: none"> <li>• Make sure that you take only the amount the doctor prescribes.</li> <li>• Make sure that you drink plenty of fluids.</li> </ul>
<b>Humibid</b> ®	Mucolytic	Decreases the thickness of the secretions.	<ul style="list-style-type: none"> <li>• Irritation of the mouth</li> <li>• Nausea</li> <li>• Nasal Stuffiness</li> </ul>	<ul style="list-style-type: none"> <li>• Make sure that you drink plenty of fluids.</li> </ul>
<b>Mucomyst</b> ®	Mucolytic	Decreases the thickness of the secretions.	<ul style="list-style-type: none"> <li>• Irritation of the mouth</li> <li>• Nausea</li> <li>• Nasal Stuffiness</li> </ul>	<ul style="list-style-type: none"> <li>• Make sure that you drink plenty of fluids.</li> </ul>



# Glossary

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<b>Assistive Cough</b>	A technique used to help individuals cough more effectively.
<b>Blood Gas</b>	A blood test to determine how well an individual is breathing.
<b>Broncho-dilator</b>	A medication that relaxes and opens the airways.
<b>Broncho-relaxer</b>	A medication that relaxes the airways.
<b>Bronchoscopy</b>	A procedure where a tube is inserted into the person's lungs, allowing specialists to see what is occurring. The procedure may be used to make a diagnosis or as a way of removing secretions that may be trapped in the lungs.
<b>Chest Percussion</b>	A method of using your hands to clap on a person's chest wall and back in an effort to make it easier for the secretions to be drained.
<b>Cuffed Tube</b>	A type of tracheostomy tube that has a balloon on it. This balloon provides protection to the airway and decreases the amount of air that escapes.
<b>Endotracheal Tube</b>	A tube that is inserted through the nose or mouth into the trachea, providing a passageway for air to be delivered either by a ventilator or an Ambu <sup>®</sup> bag.
<b>Expiration</b>	The process of exhaling carbon dioxide and other waste products.
<b>Inspiration</b>	The process of taking in air.
<b>Manual Resuscitator</b>	Assisted ventilation using a bag that is attached to the trachea and gently squeezed. This squeezing pushes air into the lungs.
<b>Mode of Ventilation</b>	The method that the ventilator uses to deliver a breath. There are several different ways that the breath can be delivered. These include: assist control mode, control mode and synchronized intermittent mandatory ventilation.
<b>Assist Control Mode</b>	The ventilator will help the individual take enough oxygen to meet his or her needs. When the ventilator is set on this mode, the person can work with the ventilator, depending on how tired he or she may be. The ventilator will make sure the prescribed number of breaths and the prescribed amount of air is given.

<b>Synchronized Intermittent Mandatory Ventilation (SIMV)</b>	The ventilator is set for the minimum number of breaths that a person needs to take. In between breaths, the person can breathe on his or her own, and the ventilator will be triggered to make sure that he or she is receiving the prescribed amount of air.
<b>Negative Inspiratory Force (NIF)</b>	The force exerted during the effort to inhale a breath against a closed meter.
<b>Non-Cuffed Tube</b>	A type of tracheostomy tube that does not have a balloon on it. This allows air to escape and does not assist in protecting the airway.
<b>Non-Fenestrated Tube</b>	A type of tracheostomy tube that does not have a hole cut into it, allowing air to escape to the upper airway. This hole, or fenestration, allows the individual to speak.
<b>Oxygen Saturation</b>	The amount of oxygen that the blood is carrying through the body.
<b>Postural Drainage</b>	A procedure that assists the person to mobilize secretions, by utilizing different positions. These positions make it easier to drain the lungs.
<b>Respiratory Rate</b>	Number of breaths that an individual takes, either on his or her own, from an Ambu bag or through a ventilator.
<b>Sensitivity</b>	The amount of effort that an individual needs to take to trigger the ventilator into the inspiratory phase.
<b>Tidal Volume</b>	The amount of air that an individual takes in without using his or her maximum effort.
<b>Tracheostomy Tube</b>	A plastic tube that is inserted into the trachea, providing a passageway for air to be delivered either by a ventilator or an Ambu bag.
<b>Weaning</b>	A decrease in the assistance that the person is receiving from the ventilator. This can be a decrease in the amount of breaths, the amount of air or the amount of time spent on the ventilator.
<b>Ventilator</b>	A machine that delivers air to a person either through an endotracheal tube (ET tube) or a tracheostomy tube.

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# Comments and Feedback

The staff of the center has recently spent a lot of time and effort in revising this manual. However, we realize that those who are actively reading and using the manual can improve it. As a part of our program of continuous quality improvement, we ask you to help guide our efforts to improve the manual.

In the next section of the chapter are two forms. The first form is an overview by chapter that seeks to identify those areas of the manual that could benefit the most from additional work. We also seek to identify any major areas of concern that have not been addressed.

The second section is a more focused questionnaire that has as its goal the specific items that should be targeted. For example, should an item be added to the glossary or the definition changed. Should a drug be added to the discussion of bowel programs?

The more specific the comments are the more likely that we will be able to make the improvements that form the basis of your idea. By communicating with the Regional Spinal Cord Injury Center of the Delaware Valley, however, users grant us permission to use any information, suggestions, ideas, drawings or concerns communicated for any purpose we choose, commercial, public or otherwise, without compensation or acknowledgement whatsoever.

Thank you for taking the time to assist us in improving this manual.

Sincerely,

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# Feedback Form

Rate each chapter by placing an “X” on the scale underneath the term that best captures your opinion. Using the next page, provide specific comments regarding your ratings. Feel free to make copies of the next page.

	No Opinion	Fair	Satisfactory	Good	Excellent
Credits / Front Matter					
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Master Glossary					

# Suggestions and Comments

Chapter: \_\_\_\_\_

Page(s): \_\_\_\_\_

Comments: \_\_\_\_\_

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Any terms that need to be added to the glossary? How would you define the terms?

Any section or paragraph that was not clear?

Any drawing or sketch that would help to illustrate the material being covered?

Any additional topic that should be covered?

Any questions you have that you feel should have been answered by the manual?

What is the question?

What is the suggested answer?

Any references that should be added? Any other resources that should be mentioned?

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