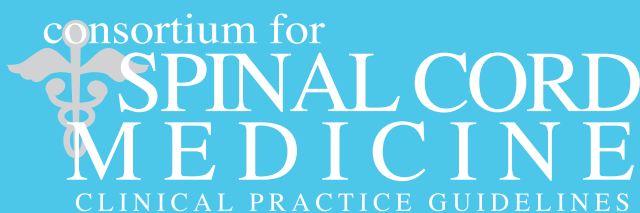


# Respiratory Management Following Spinal Cord Injury:

**A Clinical Practice Guideline  
for Health-Care Professionals**



Administrative and financial support provided by  
Paralyzed Veterans of America

# **Consortium for Spinal Cord Medicine Member Organizations**

American Academy of Orthopedic Surgeons

American Academy of Physical Medicine and Rehabilitation

American Association of Neurological Surgeons

American Association of Spinal Cord Injury Nurses

American Association of Spinal Cord Injury Psychologists and Social Workers

American College of Emergency Physicians

American Congress of Rehabilitation Medicine

American Occupational Therapy Association

American Paraplegia Society

American Physical Therapy Association

American Psychological Association

American Spinal Injury Association

Association of Academic Physiatrists

Association of Rehabilitation Nurses

Christopher Reeve Paralysis Foundation

Congress of Neurological Surgeons

Insurance Rehabilitation Study Group

International Spinal Cord Society

Paralyzed Veterans of America

U.S. Department of Veterans Affairs

United Spinal Association

# CLINICAL PRACTICE GUIDELINE

Spinal Cord Medicine

## **Respiratory Management Following Spinal Cord Injury: A Clinical Practice Guideline for Health-Care Professionals**



Consortium for Spinal Cord Medicine

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*This guideline has been prepared based on the scientific and professional information available in 2004. Users of this guideline should periodically review this material to ensure that the advice herein is consistent with current reasonable clinical practice.*

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# Preface

**O**ur panel attempted to develop guidelines that would meet the needs of a person with recent onset spinal cord injury who is in respiratory distress. This document represents the best recommendations that we could provide given the availability of scientific evidence. As chairman of the panel writing these guidelines, my goal was to gather and disseminate the best available knowledge and information about managing the respiratory needs of patients with ventilation problems. I know from many years of personal experience that the acute respiratory management of persons with spinal cord injuries is highly variable, and there is a great need for development of scientifically based standards of care. Unfortunately, our review of the available literature demonstrated that there are not widely accepted guidelines for some aspects of respiratory management because appropriate research studies have not been published for some of the topics that needed coverage. Because the scientific basis of many of our recommendations is not clearly established, wherever necessary, we developed consensus-based recommendations.

Many questions still need to be answered. What is the appropriate way to ventilate a person who has partial or complete paralysis of the muscles of respiration? What are the criteria for weaning from the ventilator? How much work does ventilation require? How can patients who have impaired ventilation put forth the additional effort required for other activities without becoming exhausted? Again, from my personal experience, many patients are suffering because of lack of answers that would allow widespread agreement on these management issues.

From the earliest days of the Consortium for Spinal Cord Medicine, we have known that scientific evidence was not always available to definitively settle all the issues that could be raised on a topic. So we include an analysis of needs for future research studies. The members of our excellent panel hope that future studies will clarify the problems and define solutions. Despite shortcomings pointed out during the review process, this document may help medical providers become more attentive to the needs of such patients.

I extend heart-felt gratitude to my colleagues on the panel for their faithful work and to the reviewers for their valuable input! I also want to extend my great appreciation to the Paralyzed Veterans of America for making this effort possible. It was my great pleasure to work with all of you!

Kenneth C. Parsons, MD  
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# Acknowledgments

The chairman and members of the respiratory management guideline development panel wish to express special appreciation to the individuals and professional organizations who are members of the Consortium for Spinal Cord Medicine and to the expert clinicians and health-care providers who reviewed the draft document. Special thanks go to the consumers, advocacy organizations, and the staff of the numerous medical facilities and spinal cord injury rehabilitation centers who contributed their time and expertise to the development of this guideline.

Douglas McCrory, MD, and colleagues at Duke Evidence-based Practice Center (EPC), Center for Clinical Health Policy Research in Durham, North Carolina, served as consultant methodologists. They masterfully conducted the initial and secondary-level literature searches, evaluated the quality and strength of the scientific evidence, constructed evidence tables, and graded the quality of research for all identified literature citations. This included an update and expansion to the original scope of work in the EPC Evidence Report, Treatment of Pulmonary Disease Following Cervical Spinal Cord Injury, developed under contract 290-97-0014 with the Agency for Healthcare Research and Quality (AHRQ).

Members of the consortium steering committee, representing 19 professional, payer, and consumer organizations, were joined in the guideline development process by 30 expert reviewers. Through their critical analysis and thoughtful comments, the recommendations were refined and additional supporting evidence from the scientific literature was identified. The quality of the technical assistance by these dedicated reviewers contributed significantly to the professional consensus building that is hopefully achieved through the guideline development process. William H. Archambault, Esq., conducted a comprehensive analysis of the legal and health policy issues associated with this complex, multifaceted topic. In addition, the consortium and development panel are most appreciative for the excellent consultation and editing of the education section provided by Theresa Chase, RN, director of patient education at Craig Hospital, Englewood, Colorado.

The guideline development panel is grateful for the many technical support services provided by various departments of the Paralyzed Veterans of America (PVA). In particular, the panel recognizes J. Paul Thomas and Kim S. Nalle in the Consortium Coordinating Office for their help in organizing and managing the process; James A. Angelo, Kelly Saxton, and Karen Long in the Communications Department for their guidance in writing, formatting, and creating art; and medical editor Joellen Talbot for her excellent technical review and editing of the clinical practice guideline (CPG). Appreciation is expressed for the steadfast commitment and enthusiastic advocacy of the entire PVA Board of Directors and of PVA's senior officers, including National President Randy L. Pleva, Sr.; Immediate Past President Joseph L. Fox, Sr.; Executive Director Delatorro L. McNeal; Deputy Executive Director John C. Bollinger; and Director of Research, Education, and Practice Guidelines Thomas E. Stripling. PVA's generous financial support has made the CPG consortium and its guideline development process a successful venture.

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# Summary of Recommendations

## Initial Assessment of Acute SCI

1. Guide the initial management of people presenting with suspected or possible spinal cord injury in the field and in the emergency department using the American Heart Association and the American College of Surgeons' principles of basic life support, advanced cardiac life support, and advanced trauma life support.
2. Perform an initial history and physical exam to include the following:
  - Relevant past medical history.
  - Prior history of lung disease.
  - Current medications.
  - Substance abuse.
  - Neurologic impairment.
  - Coexisting injuries.
3. The initial laboratory assessment should include:
  - Arterial blood gases.
  - Routine laboratory studies (complete blood count, chemistry panel, coagulation profile, cardiac enzyme profile, urinalysis, toxicology screen).
  - Chest x-ray.
  - EKG.

Conduct periodic assessments of respiratory function to include:

- Respiratory complaints.
- Physical examination of the respiratory system.
- Chest imaging as indicated.
- Continuous pulse oximetry.
- Performance of the respiratory muscles: vital capacity (VC) and maximal negative inspiratory pressure.
- Forced expiratory volume in 1 second (FEV<sub>1</sub>) or peak cough flow.
- Neurological level and extent of impairment.

4. Monitor oxygen saturation and end tidal CO<sub>2</sub> to measure the quality of gas exchange during the first several days after injury in correlation with patient expression of respiratory distress.

## Prevention and Treatment of Atelectasis and Pneumonia

5. Monitor indicators for development of atelectasis or infection, including:
  - Rising temperature.
  - Change in respiratory rate.
  - Shortness of breath.
  - Increasing pulse rate.
  - Increasing anxiety.
  - Increased volume of secretions, frequency of suctioning, and tenacity of secretions.
  - Declining vital capacity.
  - Declining peak expiratory flow rate, especially during cough.
6. Intubate the patient for the following reasons:
  - Intractable respiratory failure, especially if continuous positive airway pressure (CPAP) and bi-level positive airway pressure (BiPAP) or noninvasive ventilation has failed.
  - Demonstrable aspiration or high risk for aspiration plus respiratory compromise.
7. If the vital capacity shows a measurable decline, investigate pulmonary mechanics and ventilation with more specific tests.
8. Implement the following steps to clear the airway of secretions:
  - Assisted coughing.
  - Use of an in-exsufflator/exsufflator.
  - Intermittent Positive Pressure Breathing (IPPB) "stretch."
  - Glossopharyngeal breathing.
  - Deep breathing and coughing.
  - Incentive spirometry.
  - Chest physiotherapy.

- Intrapulmonary percussive ventilation.
  - Continuous positive airway pressure (CPAP) and bi-level positive airway pressure (BiPAP).
  - Bronchoscopy.
  - Positioning (Trendelenburg or supine).
9. Determine the status of the movement of the diaphragm (right and left side) by performing a diaphragm fluoroscopy.
10. Successful treatment of atelectasis or pneumonia requires reexpansion of the affected lung tissue. Various methods include:
- Deep breathing and voluntary coughing.
  - Assisted coughing techniques.
  - Insufflation—exsufflation treatment.
  - IPPB “stretch.”
  - Glossopharyngeal breathing.
  - Incentive spirometry.
  - Chest physiotherapy.
  - Intrapulmonary percussive ventilation (IPV).
  - Continuous positive airway pressure (CPAP) and bi-level positive airway pressure (BiPAP).
  - Bronchoscopy with bronchial lavage.
  - Positioning the patient in the supine or Trendelenburg position.
  - Abdominal binder.
  - Medications.

## Mechanical Ventilation

### Indications for Mechanical Ventilation

#### Respiratory Failure

#### Intractable Atelectasis

11. If the patient needs mechanical ventilation, use a protocol that includes increasing ventilator tidal volumes to resolve or prevent atelectasis.
12. Set the ventilator so that the patient does not override the ventilator settings.

## Surfactant, Positive-End Expiratory Pressure (PEEP), and Atelectasis

13. Recognize the role of surfactant in atelectasis, especially when the patient is on the ventilator.

## Complications of Short-Term and Long-Term Ventilation

### Atelectasis

14. Use a protocol for ventilation that guards against high ventilator peak inspiratory pressures. Consider the possibility of a “trapped” or deformed lung in individuals who have trouble weaning and have had a chest tube or chest surgery.

### Pneumonia

15. Employ active efforts to prevent pneumonia, atelectasis, and aspiration.

### Pulmonary Embolism and Pleural Effusion

16. Monitor ventilated patients closely for pulmonary embolism and pleural effusion.

### Long-Term Ventilation

17. Evaluate the need for long-term ventilation.
  - Order equipment as soon as possible.
  - If a ventilator is needed, recommend that patients also have a backup ventilator.

## Weaning from the Ventilator

18. Consider using progressive ventilator-free breathing (PVFB) over synchronized intermittent mandatory ventilation (SIMV).

### PVFB Versus SIMV

### Partial Weaning

## Electrophrenic Respiration

19. For apneic patients, consider evaluation for electrophrenic respiration.
20. Consider the advantages of acute and long-term use of noninvasive ventilation over initial intubation and long-term tracheostomy if the treatment staff has the expertise and experience in the use of such devices.

## Sleep-Disordered Breathing

21. Perform a polysomnographic evaluation for those patients with excessive daytime sleepiness or other symptoms of sleep-disordered breathing.
22. Prescribe positive airway pressure therapy if sleep-disordered breathing is diagnosed.

## Dysphagia and Aspiration

23. Evaluate the patient for the following risk factors:
  - Supine position.
  - Spinal shock.
  - Slowing of gastrointestinal tract.
  - Gastric reflux.
  - Inability to turn the head to spit out regurgitated material.
  - Medications that slow gastrointestinal activity or cause nausea and vomiting.
  - Recent anterior cervical spine surgery.
  - Presence of a tracheostomy.
  - Advanced age.
24. Prevent aspiration by involving all caregivers, including respiratory therapists, speech therapists, physical therapists, pharmacists, nurses, and physicians, in the care of the patient.
  - Institute an alert system for patients with a high risk for aspiration.
  - Position the patient properly.
  - Ensure easy access to a nurse call light and alarm system.
  - Have the patient sit when eating, if possible.
  - Screen patients without a tracheostomy who have risk factors or signs and symptoms of dysphagia.
  - If the patient is found to be aspirating and is on large ventilator tidal volumes, monitor the peak inspiratory pressure closely.
25. Consider a tracheostomy for patients who are aspirating. If the patient has a tracheostomy and is aspirating, the tracheostomy cuff should only be deflated when the speech therapist—and possibly a nurse or respiratory therapist as well—is present. (All involved personnel should be expert in

suctioning.) Monitor SPO<sub>2</sub> as an early indicator of an aspiration impact.

## Psychosocial Assessment and Treatment

### Adjustment to Ventilator-Dependent Tetraplegia

26. Consider the manner in which the individual is accommodating to the spinal cord injury, including the individual's post-injury psychological state.

### Enhancement of Coping Skills and Wellness

27. Assist the patient and family in the development, enhancement, and use of coping skills and health promotion behaviors.

### Affective Status

28. Monitor the patient's post-injury feeling states, specifically for the emergence of depression and anxiety.

### Substance Abuse

29. Assess the patient for the presence of comorbid substance abuse beginning in the acute rehabilitation setting.

### Pain

30. Assess the patient's level of pain, if any, and establish the type of pain to determine the most appropriate physical and psychological treatment modalities.

### Secondary Mild Brain Injury

31. Assess for possible comorbid brain trauma as indicated by the clinical situation.

### Decision-Making Capacity

32. Determine the individual's capacity to make decisions and give informed consent on medical-related issues by examining the following:
  - Organicity.
  - Medications.
  - Psychological reactions.
  - Pre-morbid substance abuse.
  - Pain.

### Advance Directives

33. Discuss advance directives, specifically the living will and durable power for medical health care, with the competent patient or the patient's proxy to determine the validity of the documents post trauma.

### Family Caregiving

34. As appropriate, assess and support family functioning.

### Intimacy and Sexuality

35. Explore issues of intimacy and sexuality with the patient and other appropriate parties.

### Establishment of an Effective Communication System

36. Assess the patient's ability to communicate, and ensure that all staff can effectively interact with the patient to determine his or her needs and concerns.

## Education Program Development

37. Plan, design, implement, and evaluate an educational program to help individuals with SCI and their families and caregivers gain the knowledge and skills that will enable the individual to maintain respiratory health, prevent pulmonary complications, return home, and resume life in the community as fully as possible.

## Discharge Planning

38. Working with the multidisciplinary rehabilitation team, the patient, and his or her family, develop a discharge plan to assist the individual with ventilator-dependent spinal cord injury in transitioning from the health-care facility to a less restrictive environment, preferably a home setting.

### Home Modifications

39. Evaluate and then modify the home environment to accommodate the demands of wheelchair access and respiratory equipment.

### Caregivers

40. Home health-care workers, family members, privately hired assistants, and others trained in personal care and respiratory management of the

individual with spinal cord injury should provide care or be available to assist the patient 24 hours a day. Efficient care of the patient depends on careful charting by home caregivers and proper management of the home medical supply inventory.

### Durable Medical Equipment

41. Prescribe the appropriate durable medical equipment for home use based on the evaluations of therapy staff and the patient. Consider emergency provisions (e.g., backup generator and alarms) and assistive technology as part of a safe and effective environment.

### Transportation

42. Use a van equipped with a lift and tie downs or accessible public transportation to transport the person with ventilator-dependent spinal cord injury. The patient should be accompanied by an attendant trained in personal and respiratory care.

### Finances

43. Evaluate thoroughly the patient's personal and financial resources and provide expert guidance in applying for benefits and coordinating assets to maximize all available resources.

### Leisure

44. Explore and provide information on diversionary pursuits, leisure interests, local community resources, and adaptive recreational equipment.

### Vocational Pursuits

45. Arrange a vocational evaluation to determine special aptitudes, interests, and physical abilities; factor in the need for transportation and attendant services.

### Transition Resources

46. Identify medical and other transition resources in the home community, including:
- Local specialists.
  - Respiratory services.
  - Home supply and durable medical equipment vendors.
  - Pharmacies.
  - Home health-care services.
  - Advocacy groups.

# The Consortium for Spinal Cord Medicine

**S**eventeen organizations, including PVA, joined in a consortium in June 1995 to develop clinical practice guidelines in spinal cord medicine. A steering committee governs consortium operation, leading the guideline development process, identifying topics, and selecting panels of experts for each topic. The steering committee is composed of one representative with clinical practice guideline experience from each consortium member organization. PVA provides financial resources, administrative support, and programmatic coordination of consortium activities.

After studying the processes used to develop other guidelines, the consortium steering committee unanimously agreed on a new, modified, clinical/epidemiologic evidence-based model derived from the Agency for Healthcare Research and Quality (AHRQ). The model is:

- Interdisciplinary, to reflect the numerous informational needs of the spinal cord medicine practice community.
- Responsive, with a time line of 12 months for completion of each set of guidelines.
- Reality-based, to make the best use of the time and energy of the busy clinicians who serve as panel members and field expert reviewers.

The consortium's approach to the development of evidence-based guidelines is both innovative and cost-efficient. The process recognizes the specialized needs of the national spinal cord medicine community, encourages the participation of both payer representatives and consumers with spinal cord injury, and emphasizes the use of graded evidence available in the international scientific literature.

The Consortium for Spinal Cord Medicine is unique to the clinical practice guidelines field in that it employs highly effective management strategies based on the availability of resources in the health-care community; it is coordinated by a recognized national consumer organization with a reputation for providing effective service and advocacy for people with spinal cord injury and disease; and it includes third-party and reinsurance payer organizations at every level of the development and dissemination processes. The consortium expects to initiate work on two or more topics per year, with evaluation and revision of previously completed guidelines as new research demands.

## Guideline Development Process

The guideline development process adopted by the Consortium for Spinal Cord Medicine consists of twelve steps, leading to panel consensus and organizational endorsement. After the steering committee chooses a topic, a panel of experts is selected. Panel members must have demonstrated leadership in the topic area through independent scientific investigation and publication. Following a detailed explication and specification of the topic by select steering committee and panel members, consultant methodologists review the international literature; prepare evidence tables that grade and rank the quality of the research, and conduct statistical meta-analyses and other specialized studies as needed. The panel chair then assigns specific sections of the topic to the panel members based on their area of expertise. Writing begins on each component using the references and other materials furnished by the methodology support group.

After the panel members complete their sections, a draft document is generated during the first full meeting of the panel. The panel incorporates new literature citations and other evidence-based information not previously available. At this point, charts, graphs, algorithms, and other visual aids, as well as a complete bibliography, are added, and the full document is sent to legal counsel for review.

After legal analysis to consider antitrust, restraint-of-trade, and health policy matters, the draft document is reviewed by clinical experts from each of the consortium organizations plus other select clinical experts and consumers. The review comments are assembled, analyzed, and entered into a database, and the document is revised to reflect the reviewers' comments. Following a second legal review, the draft document is distributed to all consortium organization governing boards. Final technical details are negotiated among the panel chair, members of the organizations' boards, and expert panelists. If substantive changes are required, the draft receives a final legal review. The document is then ready for editing, formatting, and preparation for publication.

The benefits of clinical practice guidelines for the spinal cord medicine practice community are

numerous. Among the more significant applications and results are the following:

- Clinical practice options and care standards.
- Medical and health professional education and training.
- Building blocks for pathways and algorithms.
- Evaluation studies of guideline use and outcomes.
- Research gap identification.
- Cost and policy studies for improved quantification.
- Primary source for consumer information and public education.
- Knowledge base for improved professional consensus building.

## Methodology

### Literature Search

For this guideline on respiratory management, a literature search was designed to identify empirical evidence on patients with acute traumatic cervical SCI, regardless of the degree of completeness of injury. We focused on the period of days to months following acute injury as well as on the long-term followup over years. Excluded from consideration were nonpulmonary complications of SCI and venous thromboembolism/pulmonary embolus. The evidence does not cover patients with SCI occurring below the cervical level or respiratory muscle weakness caused by neuromuscular or other spinal cord diseases, such as Guillain-Barré syndrome and polio. The databases searched for literature were MEDLINE (1966–Dec 2000), HealthSTAR (1975–Dec 2000), Cumulative Index to Nursing & Allied Health Literature (CINAHL) (1983–Jan 2001), and EMBASE (1980–Feb 2000). The search strategies combined an SCI concept (implemented using MeSH terms spinal cord injuries, paraplegia, and quadriplegia [exploded] and text words for tetraplegia, quadriplegia, and paraplegia) with a pulmonary disease concept. The search was limited to articles pertaining to humans and published in the English language.

Empirical studies or review articles were included after screening by the following criteria:

1. The study population includes traumatic cervical SCI.

2. The study question relates to the research questions described above.
3. The study includes data on health outcomes, health services utilization, economic outcomes, or physiological measures related to respiratory status.
4. The study design is controlled trial, prospective trial with historical controls, prospective or retrospective cohort study, or case series with 10 or more subjects.

Articles were excluded when the study population was children (all subjects or mean age < 18 years) or when the study design a case series with fewer than 10 subjects or a case report. Each article was independently reviewed by at least two investigators.

### Grading of Articles

For grading internal validity, the investigators employed the hierarchy outlined in Table 1.

**TABLE 1**  
**Hierarchy of the Levels of Scientific Evidence**

Level	Description
I	Large randomized trials with clear-cut results (and low risk of error)
II	Small randomized trials with uncertain results (and moderate to high risk of error)
III	Nonrandomized trials with concurrent or contemporaneous controls
IV	Nonrandomized trials with historical controls
V	Case series with no controls

Each study was also evaluated for factors affecting external validity using the following criteria:

- Were the criteria for selection of patients described?
- Were patients included in the study adequately characterized with regard to level and completeness of SCI?
- Were criteria for outcomes clearly defined (e.g., timing, measurement, reliability)?
- Was the clinical care of patients adequately described to be able to be reproduced?
- Were the results reported according to level of injury (minimum high cervical [C4 or above] versus low cervical [below C4]) or ventilation status (independently breathing versus ventilator dependent)?



These items were not aggregated into an overall quality score, but were considered individually. Studies meeting the above criteria were summarized in the AHRQ evidence report or in update reports, which included additional topics searched expressly for this guideline, prepared for the expert guideline panel. Additional studies that do not meet the above criteria are cited in some sections of the report when sufficient high-quality evidence on the target population was not available. These studies are not graded according to the quality criteria.

## Grading the Guideline Recommendations

After panel members had drafted their sections of the guideline, each recommendation was graded according to the level of scientific evidence supporting it. The framework used by the methodology team is outlined in Table 2. It should be emphasized that these ratings, like the evidence table ratings, represent the strength of the supporting evidence, not the strength of the recommendation itself. The strength of the recommendation is indicated by the language describing the rationale.

**TABLE 2**  
Categories of the Strength of Evidence Associated with the Recommendations

Category	Description
A	The guideline recommendation is supported by one or more level I studies.
B	The guideline recommendation is supported by one or more level II studies.
C	The guideline recommendation is supported only by one or more level III, IV, or V studies.

Sources: Sackett, D.L., Rules of evidence and clinical recommendation on the use of antithrombotic agents, *Chest* 95 (2 Suppl) (1989), 2S-4S; and the U.S. Preventive Health Services Task Force, *Guide to Clinical Preventive Services*, 2nd ed. (Baltimore: Williams and Wilkins, 1996).

Category A requires that the recommendation be supported by scientific evidence from at least one properly designed and implemented randomized, controlled trial, providing statistical results that consistently support the guideline statement. Category B requires that the recommendation be supported by scientific evidence from at least one small randomized trial with uncertain results; this category also may include small randomized trials with certain results where statistical power is low. Category C recommendations are supported by either nonrandomized, controlled trials or by trials for which no controls are used.

If the literature supporting a recommendation comes from two or more levels, the number and level of the studies are reported (e.g., in the case of a recommendation that is supported by two studies, one a level III, the other a level V, the “Scientific evidence” is indicated as “III/V”). In situations in which no published literature exists, consensus of the panel members and outside expert reviewers was used to develop the recommendation and is indicated as “Expert consensus.”

## Grading of Panel Consensus

The level of agreement with the recommendation among panel members was assessed as either low, moderate, or strong. Each panel member was asked to indicate his or her level of agreement on a 5-point scale, with 1 corresponding to neutrality and 5 representing maximum agreement. Scores were aggregated across the panel members and an arithmetic mean was calculated. This mean score was then translated into low, moderate, or strong, as shown in Table 3. A panel member could abstain from the voting process for a variety of reasons, including, but not limited to, lack of expertise associated with the particular recommendation.

**TABLE 3**  
Levels of Panel Agreement with the Recommendations

Level	Mean Agreement Score
Low	1.0 to less than 2.33
Moderate	2.33 to less than 3.67
Strong	3.67 to 5.0

# Recommendations

## Initial Assessment of Acute SCI

- 1. Guide the initial management of people presenting with suspected or possible spinal cord injury in the field and in the emergency department using American Heart Association and American College of Surgeons principles of basic life support, advanced cardiac life support, and advanced trauma life support.**

(Scientific evidence–V; Grade of recommendation–C; Strength of panel opinion–Strong)

Guidelines from the American Heart Association and the American College of Surgeons suggest the professional standard for emergency care of respiratory and cardiovascular emergencies. The guidelines are evidence based and are regularly reviewed and changed as warranted. They apply to the needs of spinal cord injured individuals during the emergency and urgent phases of care.

- 2. Perform an initial history and physical exam to include the following:**

- Relevant past medical history.
- Prior history of lung disease.
- Current medications.
- Substance abuse.
- Neurologic impairment.
- Coexisting injuries.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Note: See Recommendation 3 Rationale.

- 3. The initial laboratory assessment should include:**

- Arterial blood gases.
- Routine laboratory studies (complete blood count, chemistry panel, coagulation profile, cardiac enzyme profile, urinalysis, toxicology screen).
- Chest x-ray.
- EKG.

Conduct periodic assessments of respiratory function to include:

- Respiratory complaints.
- Physical examination of the respiratory system.
- Chest imaging as indicated.
- Continuous pulse oximetry.
- Performance of the respiratory muscles: vital capacity (VC) and maximal negative inspiratory pressure.
- Forced expiratory volume in 1 second (FEV1) or peak cough flow.
- Neurological level and extent of impairment.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Pulmonary problems are a common comorbidity of spinal cord injury, especially among cervical and higher thoracic injuries. Clinical assessment, including respiratory rate and pattern, patient complaints, chest auscultation, and percussion, significantly contributes to the initial and ongoing management of people with higher spinal cord injuries. Objective, reproducible measures of pulmonary mechanics should document all sequential trends in respiratory function. By following these parameters closely, new deficits in function can be identified and treated in a controlled fashion before they become clinically urgent.

In the hours and days after injury, the neurological level of injury can ascend, causing changes in respiratory function requiring urgent attention. In addition, people with high-level cervical injuries (C3–5) may fatigue over the course of the first few days after their injury, especially since they are unable to cough up their secretions. Common methods of evaluation, such as chest roentgenograms (x-rays), have been shown to miss significant respiratory pathologies and cannot be relied on as the sole evidence of normal function. Nevertheless, chest x-rays provide useful diagnostic information when pathology is identified.

- 4. Monitor oxygen saturation and end tidal CO<sub>2</sub> to measure the quality of gas exchange during the first several days after injury in correlation with patient expression of respiratory distress.**

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Monitoring oxygen saturation is a noninvasive way of following the quality of gas exchange. This can be a means of identifying changes in function and developing pathologies early before they become clinically urgent. Consider arterial blood gas depending on patient complaints and deterioration in oxygen saturation. Decline in oxygen saturation and increased requirement for O<sub>2</sub> supplementation may be associated with CO<sub>2</sub> retention and herald the need for initiation of mechanical ventilation.

## Prevention and Treatment of Atelectasis and Pneumonia

Pneumonia, atelectasis, and other respiratory complications, reported to occur in 40–70% of patients with tetraplegia, are the leading cause of mortality (Bellamy et al., 1973; Carter, 1987; Kiwerski, 1992; Reines and Harris, 1987). In one study, 60% of C3 and C4 patients on a ventilator who were transferred to a tertiary care facility had atelectasis (Peterson et al., 1999).

### 5. Monitor indicators for development of atelectasis or infection, including:

- Rising temperature.
- Change in respiratory rate.
- Shortness of breath.
- Increasing pulse rate.
- Increasing anxiety.
- Increased volume of secretions, frequency of suctioning, and tenacity of secretions.
- Declining vital capacity.
- Declining peak expiratory flow rate, especially during cough.

Note: If atelectasis or pneumonia is present on the chest x-ray, institute additional treatment and follow serial chest radiographs. If temperature, respiratory rate, vital capacity, or peak expiratory flow rate is trending in an adverse direction, obtain a chest radiograph.

(Scientific evidence–V; Grade of recommendation–C; Strength of panel opinion–Strong)

Because the incidence of atelectasis and pneumonia is so high in the tetraplegic patient, special attention needs to be given to monitoring

the patient for these complications. The most common location for atelectasis is the left lower lobe. The physician should attempt to roll the patient to the side or sit him or her up to fully evaluate the left lower lobe, often missed when auscultating over the anterior chest wall (Sugarman, 1985).

Other methods of evaluating the patient should be used, including the serial determination of the vital capacity, the peak expiratory flow rate, the negative inspiratory force (NIF), and oximetry. These should be followed on an individual flow sheet designed for this purpose or on a graph. If any of these measures are deteriorating, a chest radiograph should be performed. A chest radiograph should also be performed if the vital signs are deteriorating, if subjective dyspnea increases, or if the quantity of sputum changes.

The higher the level of spinal cord injury, the greater the risk of pulmonary complications. Wang et al. (1997) documented a reduction in peak expiratory flow rate in tetraplegic patients. Because peak expiratory flow rate is important in cough, it would be expected that the higher the level of SCI, the greater the likelihood of retention of secretions and atelectasis.

### 6. Intubate the patient for the following reasons:

- Intractable respiratory failure, especially if continuous positive airway pressure (CPAP) and bi-level positive airway pressure (BiPAP) or noninvasive ventilation has failed.
- Demonstrable aspiration or high risk for aspiration plus respiratory compromise.

(Scientific evidence–III; Grade of recommendation–C; Strength of panel opinion–Strong)

The decision to intubate the SCI patient is often difficult. There is evidence that patients have fewer respiratory complications on noninvasive ventilation than with invasive ventilation (Bach et al., 1998). However, unless the physicians and other staff caring for the patient have adequate experience in caring for tetraplegic patients who are not on a ventilator, it may be safer for the patient to be intubated and ventilated using the protocol outlined in Appendix A. In these situations, it is also desirable to transfer the patient to a specialized center with expertise in caring for tetraplegic patients (Applebaum, 1979; Bellamy et al., 1973).

**7. If the vital capacity shows a measurable decline, investigate pulmonary mechanics and ventilation with more specific tests.**

(Scientific evidence—NA; Grade of recommendation—NA; Strength of panel opinion—Strong)

The quickest and simplest way to follow the patient is to perform the vital capacity serially at the bedside. If the patient's vital signs deteriorate, especially the heart rate and respiratory rate, or if the vital capacity declines, confirmatory measurement of peak expiratory flow rate, FEV<sub>1</sub>, and NIF may suggest that the patient is developing atelectasis or pneumonia and that a chest radiograph is indicated. A change in the chest radiograph may indicate that a change in the medical management of the respiratory problems is warranted.

Deterioration of the patient's vital capacity, peak expiratory flow rate, FEV<sub>1</sub>, or NIF may also indicate an ascending level of injury. Therefore, deterioration in respiratory status needs to be correlated with any ongoing changes in level of injury as well as with changes in the patient's lung status. Whatever the reason, if the ventilatory status deteriorates significantly, the patient may need mechanical ventilation. (See *Mechanical Ventilation* on page 13.) Abdominal complications, such as distended bowel, can put pressure on the diaphragm and thus add to the problem of basal atelectasis. Therefore, abdominal complications need to be diagnosed and treated expeditiously.

**8. Implement the following steps to clear the airway of secretions:**

- Assisted coughing.
- Use of an in-exsufflator/exsufflator.
- IPPB "stretch."
- Glossopharyngeal breathing.
- Deep breathing and coughing.
- Incentive spirometry.
- Chest physiotherapy.
- Intrapulmonary percussive ventilation.
- Continuous positive airway pressure (CPAP) and bi-level positive airway pressure (BiPAP).
- Bronchoscopy.
- Positioning (Trendelenburg or supine).

(Scientific evidence—NA; Grade of recommendation—NA; Strength of panel opinion—Strong)

The ability of the patient to clear secretions can be assessed in the physical examination. The patient can be asked to cough, and the forcefulness of the cough can be estimated. The movement of the chest and of the abdomen with deep breaths can also be observed. These signs can be used singly or in combination, and also together with medications. (See *Medications* on page 12.)

**9. Determine the status of the movement of the diaphragm (right and left side) by performing a diaphragm fluoroscopy.**

(Scientific evidence—NA; Grade of recommendation—NA; Strength of panel opinion—Strong)

Patients with unilateral diaphragm paralysis may be more likely to develop atelectasis on the side of the paralysis of the diaphragm. Whether diaphragmatic paralysis is present can usually be inferred from the level of injury noted on radiological examinations of the cervical spine and from the neurological examination, which defines the level of sensation and paralysis of the extremities, neck, and chest muscles. However, there are some patients with unexpected bilateral or unilateral diaphragmatic paralysis.

Respiratory complications may be treated whether the patient is on or off the ventilator. If a patient has intractable unilateral atelectasis, this is a good indication for performing fluoroscopy of the diaphragms. Also, if a patient is unable to wean from the ventilator, diaphragm fluoroscopy may indicate whether there is paralysis of one or both diaphragms. Basal atelectasis, if it is adjacent to the diaphragm, can obliterate the diaphragm radiographically, and movement of the diaphragms sometimes may not be detectable fluoroscopically. In this situation, the atelectasis may have to be radiographically cleared before adequate fluoroscopic evaluation can be performed.

**10. Successful treatment of atelectasis or pneumonia requires reexpansion of the affected lung tissue. Various methods include:**

- Deep breathing and voluntary coughing.
- Assisted coughing techniques.
- Insufflation—exsufflation treatment.
- IPPB "stretch."
- Glossopharyngeal breathing.
- Incentive spirometry.
- Chest physiotherapy.

- Intrapulmonary percussive ventilation (IPV).
- Continuous positive airway pressure (CPAP) and bi-level positive airway pressure (BiPAP).
- Bronchoscopy with bronchial lavage.
- Positioning the patient in the supine or Trendelenburg position.
- Abdominal binder.
- Medications.

(Scientific evidence—III/IV; Grade of recommendation—C; Strength of panel opinion—Strong)

**Deep breathing and voluntary coughing** is a standard treatment for any patient in the postoperative state and for those with pneumonia, atelectasis, or bronchitis. There are no studies documenting effectiveness in people with tetraplegia. The vital capacity often improves with time after injury, which should help with lung inflation.

**Assisted coughing** is used extensively. Its use is often associated with use of IPPB or insufflator treatments, but it can also be helpful with postural drainage or simply to clear secretions from the throat. Manually assisted coughing has been shown to result in a statistically significant increase in expiratory peak airflow (Jaeger et al., 1993; Kirby et al., 1966). No study shows that assisted coughing by itself results in a lower incidence of atelectasis or pneumonia.

**Insufflation—exsufflation treatment** with a “coughalator” or an “in-exsufflator” machine has been used extensively. This machine delivers a deep breath and assists with exhalation by “sucking” the air out. It is often accompanied by “assisted coughing.” The object is to improve the rate of airflow on exhalation, thereby improving the clearance of mucus. The effectiveness of increasing the rate of airflow has been documented. The pressure for inspiration and the negative pressure on expiration can be set on the machine. Normally, pressures are set at a low level, perhaps 10cm H<sub>2</sub>O to start, and then increased to as high as 40cm as the individual becomes used to the sensation of the deep breath and the suction on exhalation (Bach, 1991; Bach and Alba, 1990a; Bach et al., 1998).

**IPPB “stretch”** is similar to the in-exsufflation treatment described above. IPPB is administered, usually with a bronchodilator, starting at a level of pressure of 10–15cm and increasing the pressure as the treatment progresses to as high as the

machine will go, but not exceeding 40cm of pressure (see **Appendix A** on **page 31**).

**Glossopharyngeal breathing** can be used to help the patient obtain a deeper breath. Glossopharyngeal breathing is accomplished by “gulping” a rapid series of mouthfuls of air and forcing the air into the lungs, and then exhaling the accumulated air. It can be used to help with coughing, often along with assisted coughing. Montero et al. (1967) showed improvement from 35% predicted to 65% of predicted vital capacity after training in glossopharyngeal breathing and also improvements in maximum expiratory flow rate, maximum breathing capacity, and breath-holding time. Loudness of the voice also improved (Montero et al., 1967).

**Incentive spirometry** is a technique that uses a simple bedside device allowing the patient to see how deep a breath is being taken. It is widely used with other patients as well, such as the able-bodied patient who is post-op. It is something that the tetraplegic patient’s family members can help with, thereby involving them in the daily care of their loved one. The concept is a good one, although there are no documented studies indicating efficacy in tetraplegic patients.

**Chest physiotherapy**, along with positioning of the patient, is a logical form of therapy to prevent and treat respiratory complications. However, some patients may not be able to assume the head down position to facilitate drainage of the lower lobes because of the effect of gravity pulling their abdominal contents against their diaphragm, thereby further compromising their already limited ability to take a deep breath. Also, positioning of the patient with the head down may increase gastroesophageal reflux or emesis. Positioning is sometimes difficult for patients with halo-vest immobilization. There are no studies indicating the efficacy of chest physiotherapy and positioning in tetraplegic patients.

**Intrapulmonary percussive ventilation (IPV)** can be done with the ventilator, and a similar concept can be used in the form of a “flutter valve” during nebulizer treatments. Patients report that secretions are loosened with these techniques; however, there are no reports that objectively document the efficacy of these procedures.

**CPAP and BiPAP** can be used to rest the nonintubated patient and also to give the patient a deep breath to help with managing secretions. A face-mask or a mouthpiece can be used. These techniques are used extensively in some institutions. CPAP and BiPAP may be useful in the short term

to get the patient over the acute phase after injury and may keep some patients from needing intubation or a tracheostomy.

**Bronchoscopy** can be useful in clearing the lungs of mucus that the patient cannot raise, even with the help of the above listed modalities. The bronchoscopy can be performed whether the patient is on or off the ventilator. It should be kept in mind that the bronchoscopy is used to clear the airway of secretions, not to inflate the lung (unless it is done with a method for inflating the lung through the bronchoscopy). Just clearing the lungs of the mucus will not be adequate treatment by itself. Other treatments must be instituted to inflate the lungs and prevent reaccumulation of secretions.

**Positioning the patient in the supine or Trendelenburg position** improves ventilation. Forner et al. (1977) studied 20 patients with C4–8 tetraplegia and found that the mean value of the forced vital capacity was 300ml higher in the supine or Trendelenburg positions than in the sitting position. Linn et al. (2000) studied the vital capacities of patients when supine and when sitting. They found that most tetraplegic patients had increases in vital capacity and FEV1 when supine, compared to the erect position.

**Abdominal binders** offer no pulmonary advantage for the typical patient with cervical spinal cord injury when positioned supine in bed. However, the observed 16–28% increment of vital capacity of tetraplegic patients when supine, compared to sitting, can be eliminated by wearing an abdominal binder (Estenne and DeTroyer, 1987; Fugl-Meyer, 1971). An abdominal binder acts to keep the abdominal contents from falling forward and exerts a traction effect on the diaphragm. Therefore, especially in the early phases of injury, it is helpful for the patient to wear a binder when sitting up in a chair. Some patients will regain some muscle tone in the abdomen and/or adapt to the problem in time after the injury; these patients can sometimes stop using the abdominal binder.

## Medications

Consider the following in a comprehensive medical management program.

**Bronchodilators.** Long-acting and short-acting Beta agonists should be used concomitantly to reduce respiratory complications in tetraplegics and those with lower level lesions that are prone to respiratory complications. In addition to the direct benefits of bronchodilation, these agents

promote the production of surfactant and help diminish atelectasis. Studies have not assessed the long-term benefits of bronchodilator therapy in this population but do suggest that use may mimic the reduction in respiratory symptoms seen with airway hyperactivity in able-bodied patients.

Spungen et al. (1993) and Almenoff et al. (1995) demonstrated that greater than 40% of nonacute dyspneic tetraplegics administered metaproterenol or ipratropium responded with an improvement in FEV1 of at least 12%. Although the use of ipratropium is recommended initially, it should be discontinued after stabilization since the anticholinergic effects may thicken secretions and diminish optimal respiratory capacity. There is also evidence in the literature that atropine blocks the release of surfactant from the type II alveolar cells. Because ipratropium is an atropine analogue, some experts believe that ipratropium should not be used in spinal cord injured patients, since the production of surfactant is essential for prevention and treatment of atelectasis.

**Cromolyn sodium.** Cromolyn sodium is an inhaled anti-inflammatory agent that is used in asthma. Theoretically, since tetraplegic patients have bronchospasm and inflammation, it would be helpful in tetraplegia; however, there are no studies of cromolyn sodium in tetraplegia.

**Steroids.** Other than in the setting of acute spinal cord injury and those with an asthmatic component of reactive airway disease, these agents should be reserved for short-term use in acute respiratory distress. Aged patients administered intravenous high-dose methylprednisolone in the acute setting post injury were noted to be more prone to develop atelectasis and pneumonia (Matsumoto et al., 2001).

**Antibiotics.** Although pneumonia commonly occurs in the post-injury period and has a high mortality rate among pulmonary complications in SCI patients (DeVivo et al., 1989; Lanig and Peterson, 2000), in the absence of signs and symptoms of infection, the use of antibiotics for treatment of bacterial colonization will only foster the development of resistant organisms and is not recommended. When treatment is warranted and culture results are not yet available for optimal antibiotic selection, empiric therapy should be directed to cover nosocomial bacteria (Montgomerie, 1997).

**Anticoagulation.** Current guidelines established by the Consortium for Spinal Cord Medicine call for prophylaxis with low molecular weight heparin or adjusted dose unfractionated heparin and

should begin within 72 hours of injury. Treatment should continue for 8 weeks in patients with uncomplicated complete motor lesions and for 12 weeks or until discharge from rehabilitation for those with complete motor lesions and additional risk factors. These recommendations also apply to patients with inferior vena cava filters (see the Consortium for Spinal Cord Medicine *Clinical Practice Guideline: Prevention of Thromboembolism in Spinal Cord Injury*, 2nd ed. (1999)).

**Vaccinations.** Although studies indicating a decreased incidence of influenza or pneumococcal pneumonia after vaccination are lacking in this population, vaccinations are recommended. There are no studies evaluating the efficacy of influenza vaccines, but Darouiche et al. (1993) found no differences in the immune responses to five pneumococcal polysaccharides in 40 SCI and 40 able-bodied subjects after receiving the pneumococcal vaccine. Adverse reactions occurred in approximately one-third of each group. Waites et al. (1998) evaluated the immune response in 87 SCI patients and found that at 2 months post injection 95% of patients that received the vaccine and 35% of the placebo group developed an immune response to at least one of the five serotypes tested. Approximately 93% of the vaccinated patients maintained a two-fold increase in antibody concentration to at least one serotype at 12 months post injection. This study indicated adequate pneumococcal vaccine response in SCI patients irrespective of the time of administration.

**Methylxanthines.** Methylxanthines may be of benefit in improving diaphragmatic contractility and respiratory function in this population. Studies of methylxanthines in the SCI population are lacking, and studies in other populations have produced mixed results. In a small study by Aubier et al. (1981) the efficacy of aminophylline was demonstrated via improved contractility in eight able-bodied subjects after diaphragmatic fatigue was induced via resistive breathing. A theophylline study in chronic obstructive pulmonary disease (COPD) patients by Murciano et al. (1984) produced similar results. However, another study in COPD patients by Foxworth et al. (1988) found no improvement in diaphragmatic contractility or respiratory response to theophylline.

**Anabolic steroids.** Correction of malnutrition is recommended for optimal effect on strength and endurance of the diaphragm and accessory muscles, which may assist with ventilator weaning. Short-term treatment with anabolic steroids has demonstrated promising results in this area.

Spungen et al. (1999) investigated the use of oxandrolone for strengthening of the respiratory musculature in a small uncontrolled case series. Ten complete tetraplegics were titrated to a dose of 20mg/day and treated for 30 days. Spirometry was measured at baseline and at the end of the trial. Forced Vital Capacity (FVC) increased from 2.8L to 3.0L by the end of the trial and maximal inspiratory and expiratory pressures improved by approximately 10%. Subjective symptoms of resting dyspnea also improved.

**Mucolytics.** The solubilizing effect of this therapy may make tenacious secretions easier to eliminate and may be of benefit when secretion management via other modalities has not provided adequate results. Nebulized sodium bicarbonate is frequently used for this purpose. Nebulized acetylcysteine is also effective for loosening secretions, although it may be irritating and trigger reflex bronchospasm.

**Hydrating agents.** Isotonic sterile saline given by inhalation is useful in mobilizing secretions thickened due to dehydration.

## Mechanical Ventilation

The assessment of the need for mechanical ventilation can be done using the following:

- Patient's symptoms.
- Physical examination.
- Vital capacity.
- FEV1 and NIF.
- Peak expiratory flow rate.
- Chest radiographs.
- Arterial blood gases.

The patient may complain of feeling short of breath or may experience decreased alertness or increased anxiety. Physical examination may reveal increased respiratory effort along with increased respiratory rate. The strength of the cough effort may be observed to be deteriorating, and the movement of the chest and abdomen may diminish. If the vital capacity deteriorates to the point that it is less than 10–15cc/kg of ideal body weight (approximately 1000cc for an average 80kg person) and is on a downward trend, serious consideration should be given to mechanical ventilation of the patient.

Gardner et al. (1986) emphasized that ventilation should be started before the patient reaches the point of cardiac or respiratory arrest, since

arrest can cause further damage to the spinal cord secondary to hypoxemia or hypotension. The authors suggested hourly clinical and respiratory volume and negative inspiratory pressure assessments, if indicated. They advocated early transfer to experienced spinal cord injury centers.

## Indications for Mechanical Ventilation

Respiratory failure, atelectasis, and recurrent pneumonia are common problems in the tetraplegic patient (Bellamy et al., 1973; Carter, 1987; Kiwerski, 1992; Reines and Harris, 1987). In tetraplegic patients, the forces favoring airway closure are greater than the forces favoring opening of airways. The factors favoring airway closure are:

- Weakness of inspiratory musculature.
- Loss of surfactant.
- Water in the alveoli (which can occur because of aggressive fluid resuscitation in the initial phase of the injury, when the patient may have been hypotensive).
- Pressure of subdiaphragmatic organs on the lung.

The major factor favoring opening of the airways is the negative force generated during inhalation. This force is greatly reduced in the tetraplegic patient due to paralysis. Mucus can also block the inflow of air, and the paralyzed patient has trouble keeping the airways free of mucus because of the weakness of the cough. When the airways close, lung compliance reduces because of the loss of surfactant production. Atelectatic lung produces no surfactant, but hyperinflation enhances surfactant production. If the compliance of the lung is reduced because of airway closure or plugging by mucus, it becomes more difficult for the patient to generate a breath. If it is more difficult to breathe, the patient fatigues and develops respiratory failure. If the airways can be kept open or can be reexpanded with treatment, it becomes easier for the patient to breathe. Therefore, it is very important to keep the lungs expanded, and efforts need to be maximized to effect deep breaths and clear the airways of mucus.

## Respiratory Failure

Respiratory failure is an indication for ventilation. This is defined as  $pO_2$  less than 50, or  $pCO_2$  over 50, by arterial blood gas testing, while the patient is on room air.

## Intractable Atelectasis

The patient's chest radiographs may indicate persistent atelectasis or pneumonia, intractable to noninvasive treatment. Serial chest radiographs may also indicate worsening atelectasis. If there is intractable or worsening atelectasis, particularly if the symptoms, vital signs, physical examination, vital capacity, peak expiratory flow rate,  $FEV_1$ , and NIF are deteriorating, the patient is a candidate for assisted ventilation.

### 11. If the patient needs mechanical ventilation, use a protocol that includes increasing ventilator tidal volumes to resolve or prevent atelectasis.

(Scientific evidence—V; Grade of recommendation—C; Strength of panel opinion—Strong)

The reason for ventilating patients is their inability to take a deep breath, resulting in hypoventilation, but ventilating them with small tidal volumes only perpetuates the underlying reason for initiating mechanical ventilation. Lung tissue in patients with acute spinal cord injury is usually healthy, except for atelectasis or pneumonia. Treatment on the ventilator should be designed to overcome the hypoventilation of lung tissue.

ARDS (acute or adult respiratory distress syndrome) patients have a problem with diffuse lung injury. For patients with ARDS, it is very appropriate to ventilate the patient with small breaths to avoid barotrauma. If a tetraplegic patient develops ARDS, treatment should follow a protocol for ARDS. The incidence of barotrauma and ARDS in tetraplegia has not been studied.

Peterson et al. (1999) studied patients treated during a 10-year time period who were either ventilated with relatively low tidal volumes or ventilated by means of a protocol that gradually increased their tidal volume over a period of approximately 2 weeks. All of the patients were ventilator dependent on arrival at a tertiary care facility. The average ventilator tidal volume on discharge from their previous hospital(s) was 900–1000cc for all of the patients. In the patients subsequently ventilated by means of the protocol, the incidence of atelectasis decreased from 84% on admission to 16% in 2 weeks, whereas those patients ventilated with small tidal volumes had an increase in incidence of atelectasis from 39% to 52% after 2 weeks. These data suggest that low ventilator tidal volumes are a cause of atelectasis and that cautious implementation of larger ventilator tidal volumes can successfully treat atelectasis.



In addition, protocol patients were totally weaned from the ventilator in an average of 37.6 days, whereas those ventilated with lower tidal volumes were weaned in an average of 58.7 days. Peterson and colleagues found no significant difference in complication rate, and only one of the 42 patients required a chest tube (requiring a chest tube was used as an indicator of barotrauma). This chest tube was required after placement of a subclavian catheter. Based on the incidence of new pneumothorax during ventilator treatment, if the patient is treated carefully, with slowly increasing ventilator tidal volumes, there is no increased risk of pneumothorax, according to this small series of patients. In this group of patients, dead space was used to control the  $p\text{CO}_2$  level.

Ordinarily, physicians use smaller ventilator tidal volumes or slower respiratory rates on the ventilator to control the  $p\text{CO}_2$  level, but doing this will cause atelectasis, or a sensation of distress in the tetraplegic patient, whereas adding dead space counteracts the hyperventilation effect of larger tidal volumes. Sometimes very large amounts of dead space will be required to keep the  $p\text{CO}_2$  at a proper level. Why the larger tidal volume group of patients weans faster is unclear. It may be that the larger tidal volumes stimulate the release of surfactant (Massaro and Massaro, 1983) and that the compliance of the lungs is thereby improved. With improved compliance, the effort necessary for the patient to ventilate the lungs spontaneously is reduced. In this group of patients, where there is hypoventilation because of the paralysis, reducing the work of ventilation will be helpful in weaning off mechanical ventilation.

## 12. Set the ventilator so that the patient does not override the ventilator settings.

(Scientific evidence—III/V; Grade of recommendation—C; Strength of panel opinion—Strong)

When initially ventilating a patient with tetraplegia, the ventilator tidal volume should be set higher than for other types of patients requiring ventilation. A recommended initial setting is 15 ml/kg (kg of ideal body weight, based on height). Depending on whether or not the subsequent chest radiographs show atelectasis, the ventilator tidal volumes can be increased in small increments on a daily basis to treat the atelectasis. The risk of barotrauma should be reduced if the peak airway pressure is kept under 40cm of  $\text{H}_2\text{O}$ .

It is preferable not to allow the tetraplegic patient to trigger the ventilator. The reason for this is that the paralysis is almost always unequal—that is, one side, including the diaphragms, may be a bit stronger than the other

side. If the patient is allowed to trigger the ventilator, because the ventilator's rate is set too low the stronger side may actually draw air out of the weaker side, contributing to the formation of atelectasis. If the  $p\text{CO}_2$  is kept in the range of 30–35mmHg, the oxygen level is kept over 65mmHg, and the pH is kept in the range of 7.45–7.50, the individual will have no stimulus to take a breath. If the patient does not initiate a breath or attempt to breathe between ventilator breaths, the individual will not “flail,” and thus will have less likelihood of developing atelectasis on the weaker side.

## Large versus Small Tidal Volumes

Patients who are recumbent require higher breath volumes, both when breathing spontaneously or when on the ventilator, in order to keep the basal areas of the lung ventilated (Bynum et al., 1976). Patients with spinal cord injury are frequently recumbent for many days or weeks after their injury. Therefore, attention needs to be paid to deep breaths.

Watt and Devine (1995) list six reasons for mechanical hyperventilation in long-term ventilatory dependence (in tetraplegic patients without a cuffed tracheostomy tube):

- Augmentation of speech.
- Prevention of atelectasis.
- Allowance for variations in minute ventilation without incurring hypoxemia.
- Prevention of a decline in static compliance.
- Suppression of residual respiratory muscle activity by lowering carbon dioxide tension.
- Prevention of patients' sensation of having insufficient ventilation.

The authors note that it is not uncommon for patients receiving positive pressure ventilation to “seek increases in their tidal volumes due to feelings of breathlessness, even in the presence of normal blood gases.” (Watt and Devine reference Estenne et al. [1983] for support of their conclusions.)

## Surfactant, Positive-End Expiratory Pressure (PEEP), and Atelectasis

### 13. Recognize the role of surfactant in atelectasis, especially when the patient is on the ventilator.

(Scientific evidence—None; Grade of recommendation—NA; Strength of panel opinion—Strong)

Atelectasis is more common in the left lower lobe than in the right. Therefore, when the patient is first intubated, some areas of the lungs may be more aerated than other areas. In this situation, it is more difficult to inflate the atelectatic lung by recruiting alveolar elements and easier to inflate the already partially inflated lung. Atelectatic lung produces no surfactant, but hyperinflation enhances surfactant production. Positive-end expiratory pressure does not stimulate surfactant production (Nicholas and Barr, 1981).

Also consider which medications stimulate surfactant production. The only medications known to stimulate surfactant production are long-acting beta agonists, short-acting beta agonists, and theophyllines (Nicholas and Barr, 1981).

## Complications of Short-Term and Long-Term Ventilation

### Atelectasis

### 14. Use a protocol for ventilation that guards against high ventilator peak inspiratory pressures. Consider the possibility of a “trapped” or deformed lung in individuals who have trouble weaning and have had a chest tube or chest surgery.

(Scientific evidence—V; Grade of recommendation—C; Strength of panel opinion—Strong)

Ventilation with low ventilator tidal volumes will allow lung deformity or lung entrapment if adhesions have formed between the visceral and parietal pleura. If the lung deformity or entrapment occurs at a low ventilator tidal volume, this may cause great difficulty in weaning the patient from the ventilator later.

Some patients have chest injury or placement of central lines associated with their spinal cord injury. These associated injuries may result in pneumothorax or hemothorax. The individual

may also develop a pneumothorax as a result of mechanical ventilation. Many physicians are reluctant to use large ventilator tidal volumes; however, Peterson et al. (1999) and Peterson et al. (1997) demonstrated no increase in barotrauma or pneumothorax in patients ventilated with very high tidal volumes when the large volumes were achieved using a protocol (see **Appendix A** on **page 31**).

Some patients may develop an empyema from pneumonia or as a result of infection of the pleural space related to contamination of this space at the time of the original injury. Patients with pneumothorax, hemothorax, or empyema may require a chest tube. In some of these patients, the presence of blood or empyema in the pleural space or the presence of a chest tube may result in deformity of the lung, adhesions between the lung and the chest wall, or a trapped lung. Because these patients are weak, the lung constriction of the trapping, or the deformity, may interfere with total weaning from the ventilator. Surgical treatment and high postoperative tidal volumes should re-expand the affected lung and allow easier weaning.

### Pneumonia

### 15. Employ active efforts to prevent pneumonia, atelectasis, and aspiration.

(Scientific evidence—IV/V; Grade of recommendation—C; Strength of panel opinion—Strong)

Reducing the incidence of atelectasis for people on a ventilator should reduce the incidence of pneumonia because the bacteria will not have the medium of secretions for their growth. Pneumonia is common in tetraplegia, although it is sometimes difficult to sort out whether the patient has pneumonia, atelectasis, or both. The underlying problem is paralysis of the respiratory muscles, which leads to poor mobilization of secretions, bacterial accumulation in the secretions, and the resultant respiratory infection. Therefore, the goal for prevention and treatment of pneumonia is to mobilize the secretions.

**Prevention and Treatment of Atelectasis and Pneumonia** (see **page 9**) details treatments that can be considered to accomplish this goal. If the patient is on a ventilator, some of these treatments can also be used. However, the most important goal is to prevent the accumulation of secretions and the formation of atelectasis. If the patient develops respiratory infection and pneumonia, the result is likely to be a cascade effect of bacteria that are more and more resistant to antibiotics. Therefore, vigorous treatment to clear secretions and clear atelectasis must be instituted. The best data on clearing atelectasis and improving weaning

time indicate that the most effective approach is to follow a clinical pathway and a protocol for ventilation (Peterson et al., 1994; Peterson et al., 1997; Peterson et al., 1999; Vitaz et al., 2001).

## Pulmonary Embolism and Pleural Effusion

### 16. Monitor ventilated patients closely for pulmonary embolism and pleural effusion.

(Scientific evidence—V; Grade of recommendation—C; Strength of panel opinion—Strong)

Although pulmonary embolus is not directly related to mechanical ventilation, various studies have indicated a high incidence of pulmonary embolism in spinal cord injury. Therefore, it is imperative that the attending physician be alert to this possibility and institute prompt treatment when deep venous thrombosis (DVT) or pulmonary embolus is diagnosed. Readers are referred to the Consortium for Spinal Cord Medicine *Clinical Practice Guideline: Prevention of Thromboembolism in Spinal Cord Injury*, 2nd ed. (1999).

Although data on the frequency of pleural effusion in tetraplegia are limited, the condition does sometimes occur. It can take the form of empyema if the effusion is infected. If there is pneumonia, the infection may spread from the lungs to the pleural space; therefore, it is important to try to prevent pneumonia. The pleural effusion may occur because of the presence of atelectasis, leaving an area in the pleural space that has relatively low pressure and is filled by fluid. This can be prevented if the atelectasis is avoided. Pleural effusion can be treated by treating the atelectasis. This is best accomplished by using larger ventilator tidal volumes in the patient on the ventilator.

## Long-Term Ventilation

### 17. Evaluate the need for long-term ventilation.

- Order equipment as soon as possible.
- If a ventilator is needed, recommend that patients also have a backup ventilator.

(Scientific evidence—III/V; Grade of recommendation—C; Strength of panel opinion—Strong)

Each patient must be evaluated individually for the potential need for long-term ventilation. This is because of the need to order the appropriate ventilators for long-term use. Usually the ventilators are portable, but it may be possible to use CPAP or BiPAP machines, especially if the patient

is only going to need night-time ventilation. Also, it is important to decide if the patient can be ventilated noninvasively or if it is necessary to maintain a tracheostomy tube. If a tracheostomy tube is indicated, evaluate whether the patient can have the cuff deflated for periods of time or can go to a cuffless tracheostomy tube. Experience has shown that if a cuffless tube is used, a metal tube is usually better because it causes fewer secretions. If a cuffless tracheostomy tube is used or if the cuff is deflated part of the time, then the ventilator tidal volume will need to be increased to compensate for the leak around the deflated cuff or the cuffless tracheostomy tube.

In general, large tidal volumes are better for keeping the lungs inflated and thereby avoiding atelectasis and pneumonia. Some patients will need to be ventilated for years with large ventilator tidal volumes. If the cuff is deflated or if a cuffless tracheostomy tube is used, the leak around the cuff may cause respiratory alkalosis, due to the decrease in dead space ventilation. This will be especially true if the patient is ventilated with large volumes. Usually the kidneys will compensate for the respiratory alkalosis and maintain a normal pH of the blood. Watt and Fraser (1994) studied gas tensions in patients on long-term ventilation with cuffless tracheostomy tubes. Although all of the 10 patients had carbon dioxide levels lower than the normal range, the average pH was 7.45, with a range of 7.40–7.53. This would appear to indicate renal compensation for the hypocapnia. Unless the patient has heart disease with arrhythmias or is subject to seizures, the hypocapnia will not be a threat to the patient. Bach et al. (1993) states that chronic hypocapnia may lead to increased bone resorption. However, this is a common problem in people with tetraplegia with or without chronic hypocapnia, and studying the cause of bone resorption in tetraplegic patients would be virtually impossible. Nevertheless, it may be necessary to treat with medications appropriate for the individual patient to try to prevent bone resorption.

Watt and Devine (1995) note that “theoretical adverse effects of hypocapnia include a temporary reduction in cerebral blood flow, depletion of extra cellular buffers, a shift to the left of the oxygen dissociation curve with reduced oxygen availability at the tissues, and capillary vasoconstriction and hypokalemia.” The authors further note that although patients may be “accidentally rendered alkalotic,” they had “not consistently observed adverse clinical effects” from the hypocapnia.

## Cuff Deflations

Bach and Alba (1990b) studied the efficacy of deflated cuffs and cuffless tracheostomy tubes. Ninety-one of 104 patients were able to be converted to tracheostomy tubes with no cuffs or to have the cuffs deflated; 38 of the 104 patients were high-level tetraplegics. This study also included people with other diagnoses, such as postpolio or myopathies. The study did not indicate what percentage of the 38 tetraplegic patients were able to convert to deflated cuffs or cuffless tubes.

When the patient is doing well and improvement is seen in any pneumonia or atelectasis, the cuff on the tracheostomy tube can be deflated on a part-time basis. This allows the patient to talk. Also, sometimes the patient's appetite improves with the cuff deflated and swallowing becomes easier. With the cuff deflated, if there is a one-way speaking valve in place, the patient will have a more effective cough, especially with the use of assisted coughing.

A survey of Craig Hospital, Kessler Institute for Rehabilitation, and the Institute for Rehabilitation and Research resulted in the following list of basic discharge equipment required for a spinal cord injured person with apnea to live at home.

- Portable vent, bedside.
- Portable vent, wheelchair.
- External battery and charger.
- Vent circuits.
- Heated humidifier.
- Auxiliary power source.
- Nebulizer.
- Connecting tubing.
- Portable suction machine.
- Bedside suction machine.
- Tracheostomy tubes and care kits.
- Manual resuscitator.
- Oxygen source prn.
- Pulse oximeter pm.
- Remote external vent alarm.

An auxiliary power supply is recommended because a prolonged power outage—with the potential for fatal consequences in an apneic patient—may occur at any time. Other equipment

items and supplies will also be necessary, depending upon the individual's needs and the health-care team's recommendations.

## Weaning from the Ventilator

### 18. Consider using progressive ventilator-free breathing (PVFB) over synchronized intermittent mandatory ventilation (SIMV).

(Scientific evidence—V; Grade of recommendation—C; Strength of panel opinion—Strong)

The survival rate for seriously ill ventilated patients has increased dramatically over the past several decades, increasing the importance of weaning from mechanical ventilation. DeVivo and Ivie (1995) note progressive improvement in the survival rate of SCI patients who were ventilator dependent at the time of discharge from a rehabilitation center, or who died during their hospitalization while ventilator dependent. They compared the time periods 1973–79, 1980–85, and 1986–92. DeVivo et al. (1995) note that life expectancies for SCI individuals are considerably improved for those who have been totally weaned from the ventilator when compared to those who have not been weaned from the ventilator. Although some reports indicate at least part-time long-term ventilatory support for 100% (7 of 7) patients with C4 and C5 level tetraplegics (Sortor, 1992), other reports indicate that up to 83% of C3 and C4 tetraplegic patients can be successfully weaned from mechanical ventilation (Peterson et al., 1994). Hall et al. (1999) found that hours per month of paid attendant services for ventilator-assisted patients were 135.25 hours versus 64.74 hours of paid attendant services for ventilator-independent patients.

### PVFB Versus SIMV

Only two articles report on the weaning of spinal cord injured people with well-defined levels of injury. Both studies concerned C3 and C4 tetraplegia, because these are the people in whom there is a possibility of total weaning, although success would be difficult. Peterson et al. (1994) found that for C3 and C4 individuals with tetraplegia, PVFB provides a greater chance for successful weaning from the ventilator than does IMV. The success rate was 67.6% for each period of attempted weaning using PVFB, as compared to the 34.6% success rate for each period of attempted weaning using IMV. In this study, some people had more than one attempt at weaning, and the overall success rate for total weaning from the

ventilator for the group of 52 people was 83%. PVFB was found to be more successful when weaning was attempted early after injury, and it was more successful when weaning was first attempted longer than one month post injury. Also, 71% (12 of 17) of the individuals who had failed IMV weaning were able to completely wean by the PVFB method. Four patients were discharged on partial weans, and only one was discharged on full-time ventilation.

Gardner et al. (1986) noted that “spontaneous respiration of oxygen-enriched humidified air for graded periods is more comfortable because their lack of...muscle power impairs their ability to overcome the...resistance and phase lag of most ventilators.”

## Partial Weaning

Partial weaning using PVFB has the following advantages:

- It allows the patient’s cuff to be deflated. By using a one-way speaking valve the person can talk while weaning (unless diagnosed with tracheal stenosis, which prevents air from moving around the tube and over the vocal cords; in this case, the one-way speaking valve cannot be used).
- It allows the patient to leave home without the ventilator for activities, if able to wean for a matter of hours.
- It allows the patient to be off the ventilator for transfer from bed to chair for bathing, tracheostomy changes, or tracheostomy care.
- It allows a measure of safety in the case of a power failure.
- If IMV is used as the long-term ventilator protocol, the patient will not be able to speak or leave home without the ventilator.

## Electrophrenic Respiration

### 19. For apneic patients, consider evaluation for electrophrenic respiration.

(Scientific evidence–V; Grade of recommendation–C; Strength of panel opinion–Strong)

Diaphragmatic contraction and ventilation may be restored if the spinal cord injury is above the anterior horn cells of roots C3, C4, and C5 (the phrenic nucleus). Patients are candidates for pacemaker implantation if they are apneic and have viable phrenic nerves (Glenn et al., 1976). A nerve stimulation test of the phrenic nerve in the

neck, while recording from the diaphragm on each side, will reveal whether any muscle contraction may be recordable. High frequency electrical stimulation of each phrenic nerve with simultaneous fluoroscopy of the corresponding diaphragm will reveal whether there is perceptible movement of each side. Such testing will also reveal whether the stimulation is painful to the patient.

If there is a strong contraction of each leaf of the diaphragm, the patient is a candidate for implantation of bilateral phrenic nerve pacers. After a postoperative recovery period, a progressive electrical exercise program is begun. The goal is to recondition each leaf of the diaphragm to regain strength and endurance of the diaphragmatic musculature to allow progressively longer periods of ventilation using the diaphragm alone. Vital capacity may be measured with electrical stimulation. As with progressive ventilator-free breathing for weaning, a falling vital capacity may indicate diaphragm fatigue.

Various authors have debated whether alternating single diaphragm stimulation will allow longer periods of electrophrenic ventilation. Simultaneous stimulation of each phrenic nerve seems to give more efficient ventilation. Duration of electrophrenic respiration each day may exceed 16 hours out of 24, with the patient “resting” on a positive pressure ventilator overnight. This period of rest allows physiologic recovery of the diaphragmatic muscle in anticipation of the next day’s use.

To benefit from electrophrenic respiration, a patient must have healthy lungs that are free of pneumonia, atelectasis, and excessive secretions. Family education and troubleshooting are the keys to the confident use of this technology in the home setting. Access to technological support and medical expertise for followup is crucial to the long-term success of electrophrenic respiration.

### 20. Consider the advantages of acute and long-term use of noninvasive ventilation over initial intubation and long-term tracheostomy if the treatment staff has the expertise and experience in the use of such devices.

(Scientific evidence–V; Grade of recommendation–C; Strength of panel opinion–Strong)

Patients with acute spinal cord injury who present with respiratory distress are almost all intubated to accommodate mechanical ventilation, and the majority of people who require long-term mechanical ventilation have a tracheostomy placed unless they are in a medical center that has expertise in noninvasive ventilation. There are advantages, however, for the patient to avoid initial

intubation and surgical tracheostomy for mechanical ventilation, if possible. These include the acute complications of intubation itself, the maintenance of the body's mechanism for filtering inspired air in the oro- and nasopharynx, as well as the chronic complications associated with tracheostomy tubes.

In the acute setting, patients who have mild respiratory dysfunction (low vital capacity) may be managed by noninvasive means of ventilation (Tromans et al., 1998). To be effective, bulbar muscles must be intact, and the patient must be cooperative and otherwise medically stable. Most patients with SCI have intact bulbar function and are therefore good candidates. A concern about noninvasive ventilation is the potential for emesis and aspiration, especially in the acute setting when gastric emptying is slowed, which may increase the patient's chance for acute respiratory distress syndrome (ARDS). If the facility staff do not have expertise in the use of noninvasive means of ventilation, however, it is prudent to intubate acutely injured patients immediately.

For those individuals who require long-term mechanical ventilation, potential complications of tracheostomy tubes may include granulation formation, stomal infection, tracheomalacia, tracheal perforation, stenosis, fistula formation, decreased voice volume, and inability to perform glossopharyngeal breathing (Bach et al., 1991). The use of noninvasive means for ventilation, if suitable for the individual, can decrease these issues.

Noninvasive intermittent positive pressure ventilation (NIPPV) can be delivered via oral, nasal, or oro-nasal interfaces, and can be used for full-time ventilation as well as in the sitting and supine position (Bach et al., 1990). Nasal interfaces can be used when a mouthpiece is not effective and during the night. Other negative pressure options can include the use of body ventilators, such as the iron lung, Porta-lung, cuirass, and "wrap" ventilators. Of these negative pressure body ventilators, only the cuirass can be used for ventilatory assistance in the seated position. Intermittent abdominal pressure ventilation can be used in seated patients, as it compresses the viscera, forcing exhalation, and then allows passive inhalation.

Persons with chronic spinal cord injury with a tracheostomy tube can be decannulated and managed with noninvasive means of ventilation (Bach et al., 1991; Bach and Alba, 1993). In addition, the use of noninvasive ventilation may facilitate weaning from the ventilator (Tromans et al., 1998; Bach, 1991; Bach et al., 1993). The benefits of noninvasive ventilation, aside from the complications of the tracheostomy tube, include a

decreased risk of infection, as the presence of a foreign body in the patient's trachea is avoided; a lower risk of hospital-associated pneumonia; and a greater likelihood of discharge to home.

## Sleep-Disordered Breathing

### 21. Perform a polysomnographic evaluation for those patients with excessive daytime sleepiness or other symptoms of sleep-disordered breathing.

(Scientific evidence–V; Grade of recommendation–C; Strength of panel opinion–Strong)

Persons with chronic tetraplegia have a high prevalence of sleep-disordered breathing. Although subject inclusion criteria have varied across studies, most have reported 25–45% prevalence (Short et al., 1992; Cahan et al., 1993; McEvoy et al., 1995; Burns et al., 2000; Ayas et al., 2001). The prevalence of sleep-disordered breathing in acute tetraplegia has not been reported, although most patients show obstructive sleep apnea. Central sleep apnea appears to be relatively common as well (Short et al., 1992; McEvoy et al., 1995; Burns et al., 2000). Possible risk factors for sleep-disordered breathing in persons with SCI include obesity, neurological changes, and baclofen use (Burns et al., 2000; Burns et al., 2001; Ayas et al., 2001; Klefbeck et al., 1998), although these findings have not been consistent across all studies. When sleep-disordered breathing causes significant nocturnal desaturation, tetraplegic patients are predisposed to cognitive dysfunction, with deficits in attention, concentration, memory, and learning skills (Sajkov et al., 1998). Other ventilatory disorders that occur in people with SCI, such as chronic alveolar hypoventilation, are exacerbated during sleep and may have health consequences similar to sleep apnea. Finally, nocturnal ventilatory disorders are prevalent in patients with hypoxemic or hypercapnic respiratory failure, and obstructive sleep apnea may play a role in the development of atelectasis.

Patients with signs and symptoms of sleep-disordered breathing, such as severe snoring or excessive daytime sleepiness without other causes, should undergo diagnostic evaluation. Full polysomnography with electroencephalographic monitoring is the most sensitive test for diagnosing sleep-disordered breathing in the general population. Additional signs that should prompt a polysomnographic evaluation include hypertension that is resistant to pharmacologic treatment and persistent nocturnal bradycardia. Nocturnal pulse

oximetry may be adequate for detecting severe cases; however, a normal study does not rule out sleep-disordered breathing, particularly if performed with a standard oximeter (Netzer et al., 2001; Wiltshire et al., 2001). Nocturnal oximetry, therefore, may be appropriate as a screening study in a setting where full polysomnography is not immediately available or as a follow-up study for monitoring sleep-disordered breathing.

## 22. Prescribe positive airway pressure therapy if sleep-disordered breathing is diagnosed.

(Scientific evidence–V; Grade of recommendation–C; Strength of panel opinion–Strong)

Continuous positive airway pressure (CPAP) therapy is the most commonly prescribed treatment for sleep-disordered breathing. In spite of severe sleep-disordered breathing, tetraplegic patients may have a relatively low rate of acceptance for CPAP (Burns et al., 2000; Burns et al., 2001). Bi-level positive airway pressure (BiPAP) therapy has not been evaluated for treatment of sleep-disordered breathing in people with tetraplegia, but it may be considered for patients who do not tolerate or do not show improvement with CPAP. Other forms of treatment for sleep-disordered breathing, including oral appliances and airway surgery, such as uvulopalatopharyngoplasty, also have not been studied in people with tetraplegia. A patient with severe sleep-disordered breathing secondary to upper airway obstruction may choose to retain the tracheostomy tube and leave it open during sleep.

## Dysphagia and Aspiration

The literature on the incidence of aspiration in spinal cord injury is limited. When it does occur, it is a serious risk for the individual with tetraplegia. It is a cause of aspiration pneumonia, in addition to being a cause of acute respiratory distress syndrome (ARDS). Although the risk and frequency of ARDS in people with tetraplegia has not been specifically studied, it would appear that it is not a common occurrence in this population. However, when it does occur, it greatly increases the risk of death. Recent literature on ARDS indicates that the death rate is 31–61% for people who have ARDS (Acute Respiratory Distress Syndrome Network, 2000; Bersten et al., 2002; Gattioni et al., 2001).

## 23. Evaluate the patient for the following risk factors:

- Supine position.
- Spinal shock.
- Slowing of gastrointestinal tract.
- Gastric reflux.
- Inability to turn the head to spit out regurgitated material.
- Medications that slow gastrointestinal activity or cause nausea and vomiting.
- Recent anterior cervical spine surgery.
- Presence of a tracheostomy.
- Advanced age.

(Scientific evidence–V; Grade of recommendation–C; Strength of panel opinion–Strong)

Kirshblum et al. (1999) studied the incidence of aspiration in 187 patients with acute traumatic spinal cord injury. Forty-two patients had signs or symptoms suggestive of dysphagia; follow-up evaluation with videofluoroscopic swallowing study (VFSS) was positive in 31 of the 42 patients (73.8%). Spinal surgery via anterior cervical approach ( $p < 0.016$ ), tracheostomy with mechanical ventilation ( $p < 0.01$ ), and older age ( $p < 0.028$ ) were three independent predictors of dysphagia by VFSS. Tracheostomy at admission was the strongest single predictor of dysphagia. Patients with both tracheostomy and spine surgery via an anterior cervical approach were highly likely to demonstrate dysphagia (48%). Higher level of injury and increased time between injury and rehabilitation admission slightly increased the likelihood of dysphagia. Kirshblum and colleagues note that harmful sequelae of dysphagia in SCI patients can include transient hypoxemia, atelectasis, chemical pneumonitis, mechanical obstruction, bronchospasm, and pneumonia. Bellamy et al. (1973) also noted that patients with posterior cervical spine surgery had a slightly lower incidence of pulmonary complications and postoperative infection than anterior cervical fusion. According to Kirshblum et al. (1999), Wise and Milani (1987) found as causes of aspiration position, certain neurologic factors, surgical complications, and the inability to coordinate swallowing with ventilator cycling. They also noted that complications included the anterior spine approach, dislodged strut grafts, laryngeal nerve paralysis, and postoperative edema.

Comella et al. (1992) reports that 50% of patients treated with botulinum toxin had new pharyngeal dysfunction by videofluoroscopic swallowing studies. The authors caution that muscle fibers can be adversely affected by medications, such as corticosteroids, lipid-lowering agents, colchicines, and L-tryptophan. Many of these medications are used frequently by people with tetraplegia; if there is dysphagia or aspiration and these medications are being used, consideration should be given to alternative treatment.

**24. Prevent aspiration by involving all caregivers, including respiratory therapists, speech therapists, physical therapists, pharmacists, nurses, and physicians, in the care of the patient.**

- Institute an alert system for patients with a high risk for aspiration.
- Position the patient properly.
- Ensure easy access to a nurse call light and alarm system.
- Have the patient sit when eating, if possible.
- Screen patients without a tracheostomy who have risk factors or signs and symptoms of dysphagia.
- If the patient is found to be aspirating and is on large ventilator tidal volumes, monitor the peak inspiratory pressure closely.

(Scientific evidence—NA; Grade of recommendation—NA; Strength of panel opinion—Moderate)

Prevention of aspiration needs to be a paramount consideration in the tetraplegic patient. Respiratory therapists, speech therapists, physical therapists, pharmacists, nurses, and physicians all need to be cognizant of this risk.

Positioning is important. It would be helpful if the patient could be positioned with the head down. However, most often this is not a possibility because, with the head down, the abdominal contents and diaphragm press on the lungs, thereby further compromising the breathing in a patient who is already suffering from compromised breathing. Also, these patients may have gastric atony; putting the head down may encourage reflux or vomiting. Whatever the position, it is imperative that patients have a mouth-operated alarm always within reach, so they can call for help if they reflux or vomit.

The pharmacist needs to be vigilantly involved with all tetraplegic patients and should monitor them for medications that slow the gastrointestinal tract or cause nausea (e.g., narcotics). Consideration should be given to an alert system that can

notify the staff that this patient is susceptible to aspiration. Any of the above-mentioned staff members should be able to activate the alert, perhaps based on guidelines established by the institution or by a working group composed of members of the various disciplines. The alert could consist of a large and/or brightly colored sign on the front of the chart, a sign outside the patient's door, or a sign over the patient's bed.

**25. Consider a tracheostomy for patients who are aspirating. If the patient has a tracheostomy and is aspirating, the tracheostomy cuff should only be deflated when the speech therapist—and possibly a nurse or respiratory therapist as well—is present. (All involved personnel should be expert in suctioning.) Monitor SPO<sub>2</sub> as an early indicator of an aspiration impact.**

(Scientific evidence—NA; Grade of recommendation—NA; Strength of panel opinion—Strong)

If the patient is at risk of aspiration or is actually aspirating, swallowing must be monitored by a speech therapist. The patient needs to be monitored closely for aspiration pneumonia by watching clinical signs, such as increased sputum production, increased shortness of breath, and elevated temperature. Chest radiographs should be done when appropriate. For the patient who is found to be aspirating and does not have a tracheostomy, consideration can be given to performing a tracheostomy for easy access for suctioning of aspirated material. If the patient has a tracheostomy, the cuff on the tracheostomy tube should be left inflated to reduce the chance of significant amounts of material being aspirated. The cuff should only be deflated when the speech therapist is present. If the speech therapist is not trained in endotracheal suctioning, a nurse or respiratory therapist should be present at the time the cuff is deflated.

It may also be helpful to insert the suction catheter prior to deflating the cuff and then to suction as the cuff is deflated. This will catch any material that has accumulated above the cuff that may fall into the lower trachea when the cuff is deflated. Patients who are aspirating must be monitored closely for ARDS (Acute Respiratory Distress Syndrome Network, 2000).



## Psychosocial Assessment and Treatment

Although there are few supportive studies within the psychosocial domain, the panel nevertheless thought it essential to note areas of clinical significance in the assessment and treatment of individuals with ventilator-dependent tetraplegia. The following recommendations are not meant to be exhaustive, but rather reflective of seminal issues that deserve special attention.

The psychosocial evaluation and treatment of individuals with ventilator-dependent tetraplegia are truly complex. The reader is invited to become familiar with other applicable Consortium of Spinal Cord Medicine Clinical Practice Guidelines by visiting [www.scicpg.org](http://www.scicpg.org).

### Adjustment to Ventilator-Dependent Tetraplegia

- 26. Consider the manner in which the individual is accommodating to the spinal cord injury, including the individual's post-injury psychological state.**

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

It is imperative for the treatment team to consider the manner in which an individual is accommodating to the spinal cord injury. The patient's post-injury psychological state is one of the most significant factors in the achievement of a successful outcome and in the perception of a heightened quality of life. As a result, general aspects of adjustment, accommodation, and tolerance to traumatic injury have been widely investigated (Richards, 1986; Rohe, 1998). Several of the following areas can be viewed as subtopics of the global realm of adjustment, accommodation, and tolerance to traumatic injury and compromise.

### Enhancement of Coping Skills and Wellness

- 27. Assist the patient and family in the development, enhancement, and use of coping skills and health promotion behaviors.**

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Given the magnitude of the injury and its associated compromise, it is imperative that the clinical team assists in the development, enhancement, and use of coping skills and health promotion behaviors for both patient and family

members (Lanig et al., 1996). Unfortunately, most health-care professionals—and mental health-care providers in particular—are trained in the pathology model, which tends to focus on a person's liabilities and weaknesses. Although this stance may be beneficial in some circumstances, it does not fully reflect the uniqueness of the individual and his or her support system. To achieve balance, the treatment team should build on the strengths and assets of the individual and family. Instruction in health-enhancing techniques and skill acquisition is recommended. This approach can foster a more constructive working alliance among patient, family members, and treatment team.

### Affective Status

- 28. Monitor the patient's post-injury feeling states, specifically for the emergence of depression and anxiety.**

(Scientific evidence–V; Grade of recommendation–C; Strength of panel opinion–Strong)

Successful management and regulation of feeling states are an important variable in the post-injury adjustment process. Principal concerns relate to the emergence of depressive or anxiety states, which can impede rehabilitative progress and lead to secondary complications (Elliott and Frank, 1996; Kennedy and Rogers, 2000; Craig et al., 1994). It is imperative for the treating professionals to appreciate that many false positives occur in this domain. Specifically, if the treatment team focuses exclusively upon formal DSM-IV diagnoses without an appropriate understanding of SCI, the number of individuals with SCI who receive an inaccurate diagnosis precipitously rises. For example, an individual with SCI very frequently presents with a myriad of clinical features inaccurately construed as vegetative depressive signs. As a result, the clinician should attend judiciously to the cognitive domain (e.g., feelings of worthlessness, emptiness, and hopelessness). For more specific information on this topic, please refer to the Consortium for Spinal Cord Medicine *Clinical Practice Guideline: Depression Following Spinal Cord Injury* (1998), as well as the companion consumer pamphlet, *Depression: What You Should Know: A Guide for People with Spinal Cord Injury* (1999).

### Substance Abuse

- 29. Assess the patient for the presence of comorbid substance abuse beginning in the acute rehabilitation setting.**

(Scientific evidence–V; Grade of recommendation–C; Strength of panel opinion–Strong)

It is well recognized within the spinal cord injury literature that there exists a high incidence of comorbid substance abuse (Bombardier, 2000; Heinemann, 1993; Heinemann et al., 1989). As a result, it is clinically imperative that these potential comorbidities be assessed and treated, commencing within the acute rehabilitation setting. In the assessment, the clinician should determine the degree of substance abuse or dependence, the potential need for medical detoxification, and the existence of possible comorbid psychiatric disorders; explore physical and/or sexual abuse; examine family dynamics; evaluate the person's motivation for constructive change; and develop a treatment plan, including relapse prevention. The treatment plan should link the patient with a skilled substance abuse provider. Commonly used screening and assessment measures include the Michigan Alcoholism Screening Test (MAST), the Alcohol Use Inventory (AUI), and the Addiction Severity Index (ASI) (Cushman and Scherer, 1995). Without this type of assessment and intervention, undesirable outcomes, such as relapse subsequent to acute rehabilitation, a higher incidence of secondary physical and psychological complications, additional hospitalizations, and a compromised quality of life become more likely.

## Pain

### 30. Assess the patient's level of pain, if any, and establish the type of pain to determine the most appropriate physical and psychological treatment modalities.

(Scientific evidence—NA; Grade of recommendation—NA; Strength of panel opinion—Strong)

Pain can be one of the most problematic consequences of spinal cord injury. Clinicians must accurately assess the type and location of pain (e.g., myofascial, radicular, and/or central deafferentation) and explore which physical and psychological treatment modalities are likely to be effective. If unattended, pain can have an omnipresent and deleterious impact upon rehabilitation and perceived quality of life (Britell and Mariano, 1991; Siddall et al., 1997; Putzke et al., 2000).

## Secondary Mild Brain Injury

### 31. Assess for possible comorbid brain trauma as indicated by the clinical situation.

(Scientific evidence—NA; Grade of recommendation—NA; Strength of panel opinion—Strong)

A body of empirical work addresses the issue of SCI comorbidities, specifically the potential

presence of occult, secondary mild head injury (MHI). The presence of MHI, although typically resolving 3–6 months post injury, nevertheless requires clinical sensitivity and attention, especially in the acute rehabilitative setting. The Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine defined this diagnosis as possessing at least one of the following:

1. Any loss of consciousness up to approximately 30 minutes in duration; within 30 minutes after the injury, the person must have progressed to a GCS score of 13–15.
2. Any alteration of mental state at the time of the accident (dazed, disoriented, or confused).
3. Any loss of memory for events immediately before or after the accident (retrograde or anterograde amnesia).
4. Posttraumatic amnesia not greater than 24 hours.
5. Focal neurological deficit that may or may not be transient.

It should be noted that the absence of a loss of consciousness does not exclude the possibility of a comorbid mild head injury. Prototypically, there are negative CT and/or traditional MRI findings. Nevertheless, MHI symptoms can occur in the physical, cognitive, and emotional domains. Primary physical symptoms include headaches, dizziness, sleep architecture alterations, and fatigue. Central cognitive issues include, but are not limited to, compromises in short-term memory, simultaneous processing, reaction time, attention, ability to multitask and organize, and executive functions. Affective difficulties typically involve depression, anxiety, irritability, and reduced self-esteem. As a result, a careful differential diagnostic process is essential to minimize clinical misunderstanding.

Assuredly, these physical, cognitive, and affective issues can have a deleterious impact on the rehabilitation process (Davidoff et al., 1992; Black and Desantis, 1999; Ricker and Regan, 1999).

## Decision-Making Capacity

### 32. Determine the individual's capacity to make decisions and give informed consent on medical-related issues by examining the following:

- Organicity.
- Medications.

- Psychological reactions.
- Pre-morbid substance abuse.
- Pain.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

The basis for medically related discussions is informed consent (Caplan, 1998). However, in order for informed consent to have meaning and foundation, the individual with ventilator-dependent tetraplegia must be competent to engage in this type of dialog. Decision-making capacity is a complicated issue, often involving an array of factors, all of which should be explored. These include, but are not limited to, organicity, medications, psychological reactions, pre-morbid substance abuse, and pain. Excellent references in this area include Appelbaum and Grisso (1988), Grisso (1988), and Purtilo (1986).

## Advance Directives

### 33. Discuss advance directives, specifically the living will and durable power for medical health care, with the competent patient or the patient's proxy to determine the validity of the documents post trauma.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Advance directives, specifically the living will and durable power of attorney for medical health care, are instruments that detail the nature and magnitude of desired medical care post trauma. Given the understandable quality of life issues secondary to ventilator-dependent tetraplegia that can emerge, the presence of advance directives can help the treatment team construct a clinical plan. Nevertheless, in light of the fact that individual perspectives can change after physical compromise, it is mandatory to confirm the validity of these instruments post trauma. As a result, discussions should ensue with the competent individual or patient's proxy regarding the validity of these legal instruments (Caplan et al., 1987). In those thankfully rare situations where the patient and family wish to discontinue and withdraw treatment, Butt and Scofield (1997) present a clinically, legally, and morally sound process. This process involves selecting health-care providers who demonstrate an objective, nonzealous philosophic stance toward treatment withdrawal; establishing the patient's decision-making capacity; establishing informed consent; determining the consistency of the patient's decision; exposing the patient to other similarly disabled individuals; ensuring the philosophic compatibility of the setting; obtaining

a patient and family treatment withdrawal agreement; consulting with the institution's ethics committee; understanding what the law requires, permits, and expects of health-care providers; and providing a humane death.

## Family Caregiving

### 34. As appropriate, assess and support family functioning.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Spinal cord injuries rarely exist in a vacuum—individuals come with families. In fact, the presence of a supportive and constructively involved family augurs for a more successful outcome. As such, family education, support, and reassurance are pivotal aspects of quality rehabilitation (Chan, 2000; Elliott and Shewchuk, 1998; Kreuter, 2000). Additionally, in some instances parenting issues might need to be broached (Barker and Maralani, 1997; Rintala et al., 2000).

## Intimacy and Sexuality

### 35. Explore issues of intimacy and sexuality with the patient and other appropriate parties.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

It is adamantly held that intimacy, irrespective of level of injury, can be maintained. Indeed, there can be considerable misinformation and apprehension about this important aspect of human function. The treatment team should be a significant source of information on this topic. See the following references: Ducharme (1987), Sipski and Alexander (1997), White et al. (1993a, 1993b), and Willmuth (1987).

## Establishment of an Effective Communication System

### 36. Assess the patient's ability to communicate and ensure that all staff can effectively interact with the patient to determine his or her needs and concerns.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Irrespective of the individual's level of injury, it is imperative to devote attention to the person's ability to communicate his or her needs and concerns to others. Often consultation with speech/language pathology personnel will aid this process. Treatment staff across all shifts must be cognizant of the most effective way to interact with the patient.

## Education Program Development

The respiratory management of people with SCI who are ventilator dependent requires complex physical, social, and psychological interventions. These interventions present an enormous challenge to the multidisciplinary health-care team, which must provide the educational support and self-care skills essential to long-term survival following SCI (Gardner et al., 1985; Gardner et al., 1986). People whose families and caregivers receive effective training and support during acute care and rehabilitation have fewer preventable secondary medical complications, fewer rehospitalizations, and more successful discharge outcomes (Prince et al., 1995; DiPasquale, 1986).

### 37. Plan, design, implement, and evaluate an educational program to help individuals with SCI and their families and caregivers gain the knowledge and skills that will enable the individual to maintain respiratory health, prevent pulmonary complications, return home, and resume life in the community as fully as possible.

(Scientific evidence–V; Grade of recommendation–C;  
Strength of panel opinion–Strong)

Patients, family members, and caregivers of individuals with SCI experiencing respiratory care issues need a comprehensive educational program to help them achieve the best possible outcome. To be effective, the program plan should follow these guidelines:

- Rely on established functional outcomes of the individual's respiratory function, which includes the ability to breathe with or without mechanical assistance and to adequately clear secretions (Consortium for Spinal Cord Medicine, *Clinical Practice Guideline: Outcomes Following Traumatic Spinal Cord Injury*, 1999). The program should take into consideration contextual factors such as the patient's physiological and psychosocial status, level of injury, medical stability, treatment protocols and therapies, method and place of care delivery, readiness to learn, and available resources (DiPasquale, 1986; Splaingard et al., 1983).
- Integrate patient, family, and caregiver education and support during all phases of care, from acute rehabilitation to community reintegration. The use of a clinical care pathway for spinal cord injuries, of which patient education is a critical component, has resulted in improved patient care and fewer complications (Vitaz et al., 2001).
- Provide support, reduce anxiety, clear up any misconceptions, and foster a sense of control among family members during the acute phase (Zedjlik, 1992). Establish the readiness of the patient, family members, and caregiver to learn, and engage the hands-on cooperation of family and peers in the training as soon as possible (Anderson, 1994).
- Individualize the approach to meet the specific social, emotional, educational, and cultural needs of the patient, family, and caregiver. Pay particular attention to learning styles, educational level, literacy, and fluency with English.
- Provide information in a supportive and sensitive manner, recognizing that the stress of SCI and ventilator dependency may disrupt the usual learning process. An information-only approach will not reduce anxiety among ventilator-dependent pediatric patients unless additional active relaxation components are implemented (Warzak et al., 1991).
- Prepare the patient for respiratory interventions before they occur to minimize feelings of anxiety and loss of control (La Favor, 2000). Warzak et al. (1991) suggest a relaxation package, including muscle relaxation and imagery techniques, to reduce anxiety during daily ventilator and tracheostomy care.
- Encourage the patient, family, and caregiver to actively participate in activities that foster learning about and commitment to respiratory care in real-world settings. Possibilities include trips and outings away from the health-care facility (DiPasquale, 1986; Prince et al., 1995).
- Make use of a wide variety of teaching methods, including written materials, interactive educational devices, games, SCI multimedia tools, videos, Web-based resources, individual and group sessions, and patient and family workshops (Heenan, 1999).
- Specify outcomes that are demonstrable, measurable, and observable. Evaluation and documentation of the outcomes should cover three areas: knowledge, performance of requisite skills, and feelings of confidence. Evaluation should occur throughout the process to measure the extent to which learning has occurred.

In addition, a broad range of topics should be covered:

- Anatomical structures and functions, including the effects of SCI on respiratory functions.
- Client-specific SCI issues, such as degree of independent breathing; goals and limitations of respiratory management; and respiratory health maintenance needs and requirements, including smoking cessation (Linn et al., 2000).
- Health-care procedures and treatments:
  - Cardiopulmonary resuscitation.
  - Tracheostomy care and replacement of trach tube.
  - Bronchial hygiene protocols, chest percussion, and postural drainage.
  - Strength and endurance exercises for respiratory muscles.
  - Assisted coughing.
  - Medications, inhalation therapy.
  - Safe swallowing, voice/speech production and specimen collection.
  - Potential problems and complications, infection control, and safety practices, including knowledge of health-care and other community resources.
- Commonly used respiratory supplies and equipment:
  - Mechanical ventilators; equipment malfunction or failure; hazards, alarms, and emergencies in the case of power failure.
  - Humidifiers, oximeters, end-tidal CO<sub>2</sub>.
  - Resuscitation bags.
  - Suction equipment; response to acute threatening events, such as accidental decannulation or medical deterioration of the patient. (Anderson, 1994; DiPasquale, 1986; Dougherty et al., 1995; Splaingard et al., 1983; Zedjlik, 1992).

## Discharge Planning

### 38. Working with the multidisciplinary rehabilitation team, the patient and his or her family develop a discharge plan to assist the individual with ventilator-dependent spinal cord injury in transitioning from the health-care facility to a less restrictive environment, preferably a home setting.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

The discharge plan should include the following elements:

- An environment modified to accommodate wheelchair accessibility and respiratory needs.
- Trained 24-hour assistance.
- Medical resources.
- Appropriate durable medical equipment, including respiratory equipment.
- Transportation.
- Financial resources assessment.
- Leisure interests.
- Vocational pursuits.

The discharge planning process begins in the health-care setting with a thorough evaluation of the patient, family, and social support systems; the patient's educational and vocational background; cultural influences; and financial and living resources. Careful coordination of the patient's resources and support systems is essential to a safe and efficacious discharge.

## Home Modifications

### 39. Evaluate and then modify the home environment to accommodate the demands of wheelchair access and respiratory equipment.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

The discharge setting should include adequate access and egress. It should have space for the patient to move about in his or her wheelchair; facilities for bathing or showering; and mechanisms for heating, cooling, and ventilation. The environment should be free of fire, health, and safety hazards, and it should have adequate electrical service to support the added demands of medical equipment (American Association for Respiratory Care [AARC], 1995).

## Caregivers

- 40. Home health-care workers, family members, privately hired assistants, and others trained in personal care and respiratory management of the individual with spinal cord injury should provide care or be available to assist the patient 24 hours a day. Efficient care of the patient depends on careful charting by home caregivers and proper management of the home medical supply inventory.**

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Persons with spinal cord injury who use a ventilator should be trained to be able to give explicit instructions on their personal care to assistants and caregivers. Nosek and Fuhrer (1992) studied the causal relationship between inadequate personal care assistance and poor health. For safety and consistency, caregivers should document all aspects of care; should be trained by skilled staff, particularly in respecting the directives of the patient; and should be available to the patient at all times. An inventory of medications, medical supplies, and equipment, and a reorder and maintenance schedule should be kept for easy access and reference.

## Durable Medical Equipment

- 41. Prescribe the appropriate durable medical equipment for home use based on the evaluations of therapy staff and the patient. Consider emergency provisions (e.g., backup generator and alarms) and assistive technology as part of a safe and effective environment.**

(Scientific evidence–V; Grade of recommendation–C; Strength of panel opinion–Strong)

A carefully prescribed power wheelchair allows for patient mobility, independent weight shifts, and portable ventilation. Respiratory equipment includes two portable ventilators and all ancillary supplies and equipment (e.g., suction, oxygen, IV therapy, nutritional therapy). An electric hospital bed with adjustments and appropriate overlay or mattress, a reclining padded commode chair for toileting and showering, a mechanical power lift for safe transfers, and a backup manual wheelchair are all necessary equipment (Consortium for Spinal Cord Medicine, *Clinical Practice Guideline: Outcomes Following Spinal Cord Injury* (1999). Emergency call systems and technology (e.g., environmental control system, voice-activated computer and telephone) will enhance the independence of the patient with ventilator-dependent spinal cord injury.

## Transportation

- 42. Use a van equipped with a lift and tie downs or accessible public transportation to transport the person with ventilator-dependent spinal cord injury. The patient should be accompanied by an attendant trained in personal and respiratory care.**

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Patients using a portable ventilator can be transported in a van equipped for wheelchair access, an automobile with adequate space, accessible public transportation, or an ambulance (AARC, 1995). To ensure patient safety, have a trained attendant accompany the patient and driver. With proper assistance and planning, other means of transportation, such as a commercial airline, are also possible. Check the Federal Aviation Administration Web site ([www.faa.gov/acr/access.htm](http://www.faa.gov/acr/access.htm)) for information concerning the ventilator-dependent spinal cord injured air traveler.

## Finances

- 43. Evaluate thoroughly the patient's personal and financial resources, and provide expert guidance in applying for benefits and coordinating assets to maximize all available resources.**

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

A financial evaluation should take place at the onset of the discharge planning process (AARC, 1995). It is essential to identify all available resources and to encourage the patient and family to apply for them. Examples include income assistance; medical insurance; and disability-specific, community, and public benefits.

Financial resources are fundamental to determining where and which patient needs are met. Basic needs to be met include medications, supplies, equipment, home modifications, transportation, and caregiver services. Coordinating the available benefits will maximize the services available to the patient.

## Leisure

- 44. Explore and provide information on diversionary pursuits, leisure interests, local community resources, and adaptive recreational equipment.**

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Incorporating fun and diversion into the life of the patient who is dependent on a ventilator is essential. A therapeutic recreation specialist can provide leisure resources for the patient and family in the home community. Technology and adaptive equipment might be required for some recreational activities. The benefits of socializing outside the home and being diverted from medical issues may inspire the patient to advance his or her own interests and activities.

## Vocational Pursuits

### 45. Arrange a vocational evaluation to determine special aptitudes, interests, and physical abilities; factor in the need for transportation and attendant services.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Patients who are ventilator dependent should be encouraged to pursue their vocational interests. Chapin and Kewman (2001) found many key psychological factors associated with employment, including self-esteem, optimism, pride in personal achievement, and the positive influence of role models.

State and private vocational rehabilitation agencies can provide a vocational evaluation to guide the patient to appropriate vocational choices. Schooling or other training might be necessary before employment can be secured. Transportation, manageable scheduling, support services, and accessibility in the vocational setting are essential to success.

## Transition Resources

### 46. Identify medical and other transition resources in the home community, including:

- Local specialists.
- Respiratory services.
- Home supply and durable medical equipment vendors.
- Pharmacies.
- Home health-care services.
- Advocacy groups.

(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–Strong)

Before discharge from an institutional setting, it is essential to identify the community resources that are available to provide services for the patient at home. A list of telephone numbers for key contacts is particularly helpful. A safe and efficient transition can help to alleviate the anxiety of leaving a stocked and staffed inpatient setting for life in the home setting. The successful transitional experience will empower the patient and family to manage care needs at home and to start to normalize the life of the patient.

# Recommendations for Future Research

A number of questions concerning the respiratory management of people with spinal cord injury need further research:

- What is the importance of clearing atelectasis prior to discharge from the hospital?
- How does the incidence of respiratory complications in people who had residual atelectasis at discharge compare to the incidence of respiratory complications in people in whom the atelectasis had been cleared before discharge?
- What is the death rate in people discharged with atelectasis versus those discharged with no atelectasis?
- What are the death rates at 1, 2, 5, and 10 years out, considering:
  - Hospitalizations for respiratory reasons.
  - Treatment at home for respiratory cause.
  - Death from respiratory cause.
  - Percent change in protocol use over the years, correlated with time to wean.

Some literature suggests that the use of protocols improves outcomes. In this regard, it would be of interest to know:

- The percentage of people treated by protocols for acute injury management.
- Respiratory care protocols for nonventilated patients.
- Ventilator management protocols.
- Wean protocols.

The use of protocols could be studied with regard to incidence of death, incidence of atelectasis, and time to wean from the ventilator (Peterson et al., 1997; Peterson, 1999; Vitaz et al., 2001). In view of the fact that some research indicates that there is an advantage to using large ventilator tidal volumes, it would be helpful to know the incidence of patients who didn't have atelectasis upon arrival at the emergency room, but did 24–96 hours after being placed on low tidal volumes, compared to those who were placed on large tidal volumes from the initiation of ventilation (Peterson, 1997).

No literature on the incidence of ARDS in tetraplegia or the survival rate of individuals with tetraplegia who develop ARDS could be found. Also, no articles on the causes of ARDS specifically related to the tetraplegic population exist.

- Is there a relationship between ARDS and aspiration?
- How many people who aspirated had anterior fusion?
- Is there a relationship between low ventilator tidal volume and pleural effusions, given that pleural effusions develop in some individuals with tetraplegia?
- Can pleural effusions be cleared in people with atelectasis by using an increasing tidal volume protocol?
- What is the incidence of barotrauma in ventilated individuals with tetraplegia (ventilated with low versus high tidal volumes)? This would be especially interesting if the people are ventilated with a protocol that has built-in safeguards for prevention of both atelectasis and barotrauma (Peterson et al., 1997).



# Appendix A:

## Respiratory Care Protocol

The following protocol is a policy/procedure used by Craig Hospital, Englewood, Colorado (November 1996).

### Rationale:

To provide a guideline when respiratory protocol is ordered.

### Scope:

Respiratory therapists.

### Policy Statement:

When a physician writes an order for respiratory care protocol, a respiratory therapist will evaluate the patient and follow the protocol in treating the patient. On all protocol patients, a thorough evaluation will be done at least daily until the patient is taken off the service. The duration of the order will be determined by the patient's progress and outcomes.

### Procedure:

- I. The order for Respiratory Protocol is verified on the patient's chart.
  - A. Physician orders for respiratory care treatments that do not contain either a specific treatment and/or a frequency will be considered a protocol order and administered according to protocol guidelines.
  - B. If the physician order designates a frequency but no therapy mode, the prescribed frequency may be changed in keeping with the patient's condition and response to therapy according to protocol guidelines.
- II. The patient is evaluated and a course of treatment is determined by:
  - A. Diagnosis.
  - B. Patient history (respiratory problems, smoking, age, occupational exposures).
  - C. Physical assessment, BS, HR, RR, cough/secretions.
  - D. CXR, labs, PFTs, oximeter/ABGs, temperature, BP
  - E. DB&C ability.
  - F. Patient sensorium.

- III. The chosen therapy is initiated. An assessment is made of the effectiveness of the therapy and its appropriateness to the patient's condition and abilities.
- IV. The therapy is charted.
- V. An order is written specifying the therapy, frequency, medications used, ordering physician's name, and therapist's name.
  - A. Changes and discontinuance of therapy are noted as orders on the physician's order sheet.
  - B. Orders must stand for 24 hours before changes can be made. An exception is recognized if the patient's condition deteriorates, necessitating an increase in the frequency or treatment modality.
- VI. The physician must cosign the order within 24 hours.
- VII. As long as the patient is on the protocol, the therapist will evaluate the patient at least once daily.

### Diagnostic Aids

- I. The therapist may order a sputum culture if there are significant changes in the patient's secretions.
- II. Arterial blood gases (ABGs) may be ordered if the patient has any significant respiratory changes.
  - A. Confusion or obvious respiratory distress.
  - B. Cyanosis.
  - C. Unexplained tachycardia or bradycardia.
  - D. Visual disturbances in the presence of respiratory distress.
  - E. Critical or emergency situations where ABGs are necessary for treatment of the patient.
- III. Physician must be notified of the results.
- IV. Oximetry may be ordered instead of ABGs. The saturation is then used as criteria to begin O<sub>2</sub> therapy or to alter the liter flow for patients already receiving O<sub>2</sub>.

- V. All oxygen orders or changes in therapy are recorded in the physician's orders.
- A bedside spirometry may be done with the physician's approval.
  - The physician should be contacted for further direction in treating patients who show no response to therapy or improvement in clinical status within 48 hours.

### Other Respiratory Therapies That May Be Used

- I. **Incentive Spirometer (IS)**—Instruction and aiding of a patient to cough and deep breathe providing a means of measuring volume displaced.

#### INDICATIONS

- Postoperative patients who are unable or unwilling to take a deep breath because of pain.
- Postoperative patients with documented acute or chronic lung disease.
- A temperature of 38 degrees C (100.4 degrees F) or greater in a patient who is unable or unwilling to take a deep breath unassisted.
- Breath sounds are decreased, possibly indicating a postoperative atelectasis.
- Patient has radiologic confirmation of atelectasis.
- Other conditions that prevent deep inspiration.

#### GOALS

- Promote distribution of ventilation.
- Promote improvement of VC to optimize coughing.
- Prevent and treat postoperative atelectasis.

#### DISCONTINUANCE

- Patient achieves a minimum of 80% of the predicted inspiratory capacity according to nomograms for age and height.
- Patient is able to do IS on his or her own and is motivated to continue treatment without direct supervision.
- Patient's temperature is <38 degrees C; patient is ambulating; breath sounds are clear; CXR is clear.

- II. **Medication Nebulizers**—Inhaled medications delivered by nebulizer.

#### MEDICATION USED

- Albuterol 0.5cc (2.5mg) solution with 2.5cc NaCl may be ordered by the therapist.
- Patients using home nebulizer therapy may be ordered to receive the same medications as at home at the same prescribed dosage.
- Other medications may be used upon orders from the ordering physician.

#### INDICATIONS

- Bronchospasm as evidenced by wheezing.
- For subjective or objective improvement of airway obstruction as documented by a pulmonary function test or recent diagnosis.
- Patients having purulent secretions that they are unable to clear by coughing.

#### GOALS

- Relieve bronchospasm.
- Improve airway obstruction.
- Mobilize secretions.

#### DISCONTINUANCE

- Bronchospasm is relieved as evidenced by clear breath sounds. The therapist may continue the therapy on a prn basis for 24 hours to assess patient tolerance and then discontinue.
- COPD patients may be discontinued 2–3 days before discharge if they are not on home therapy.
- COPD patients may be changed to their home care level of therapy 2–3 days before going home. This may include changing a nebulizer to a metered dose inhaler. The patient's physician should be contacted to ensure agreement.
- Patient is able to clear secretions.
- Pulmonary rehabilitation may be suggested to the physician if the therapist evaluates that the patient may benefit from home therapy and education.

- III. **Intermittent Positive Pressure Breathing (IPPB)**—Use of a mechanical device to deliver a positive pressure breath upon triggering of the machine by the patient.

#### MEDICATIONS

See *Medication Nebulizers*

**INDICATIONS**

1. To administer aerosolized medications in patients who are unable to take deep breaths without mechanical assistance.
2. Quadriplegia, other forms of neuromuscular disease, or pulmonary disease that prevents the patient from taking a deep breath. This may be evidenced by a VC less than 40% of predicted.
3. In atelectasis, when other techniques have been used without success.

**GOALS**

1. Resolve atelectasis.
2. Increase inspiratory capacity and improve FVC.
3. Relieve bronchospasm.
4. Achieve adequate distribution of ventilation.

**DISCONTINUANCE**

1. Atelectasis is resolved; CXR is clear.
2. Bronchospasm is relieved as evidenced by clear breath sounds. If wheezing persists, other modalities of therapy should be considered if IPPB is no longer tolerated.
3. In quadriplegia or neuromuscular disease, the VC is greater than 40% of predicted.
4. Patient is able to clear secretions.
5. Inspiratory capacity is 80% of predicted.

IV. **Aerosol Therapy**—Administration of sterile water aerosol via aerosol mask, T-piece, trach talk, or face tent, with or without heat, for the purpose of providing moisture to the airways.

**INDICATIONS**

1. To thin and liquefy secretions, thus aiding in mucus clearance.
2. Decrease airway inflammation.
3. Sputum induction.

**DISCONTINUANCE**

1. Improvement in breath sounds.
2. Improvement in expectoration of secretions.
3. Improvement in airway inflammation.
4. Subjective improvement by patient.

# Appendix B:

## Protocol for Ventilator-Dependent Quadriplegic Patients

The following protocol is a policy/procedure used by Craig Hospital, Englewood, Colorado (March 1996).

### Rationale:

To establish guidelines to be followed for all ventilator patients: ventilator protocol patients and nonprotocol patients.

### Scope:

Respiratory therapists.

### Policy Statement:

The following procedure applies to both ventilator protocol patients and nonprotocol patients.

### Procedure:

- I. Upon admission:
  - A. Physician writes "Ventilator Protocol" when patient is admitted.
  - B. Obtain patient's height and calculate ideal body weight.
    1. Male—130lb at 5 feet tall + 5lb thereafter/in (change to kg).
    2. Female—115lb at 5 feet tall + 5lb thereafter/in (change to kg).
      - a. Calculate tidal volume of 20cc/kg ideal body weight and chart on ventilator sheet.
      - b. 2.2lbs = 1kg.
  - C. Patient to be placed on a 7200 or an Adult Star ventilator with settings as follows:
    1. MODE A/C or C.M.V.
    2. VT—set per previous hospital setting.
    3. RR—12.
    4. Sigh—200–500cc greater than the VT with rate of 8x2 per hr. Sigh volume not to exceed 2200cc.
    5. Flowrate—70 lpm.
    6. Titrate O<sub>2</sub> to maintain saturation greater than 92%.
    7. PEEP—same as previous hospital setting.
8. Vds—HME "6 in" and "8 in" flex extension for total of "14 in."
  - a. Respiratory therapist documents additional Vds.
  - b. If patient is changed to a heated water system, "6 in" more Vds must be added to replace the HME "6 in" Vds.
9. Respiratory treatments.
  - a. On admission Q4 hour MDI Rx's with Albuterol X4 puffs (all patients).
  - b. All other respiratory medications to be ordered by physicians.
  - c. MDI treatments will be changed to IPPB treatments as wean times increase.
  - d. All respiratory treatments will be according to Protocol after the patient has weaned from the ventilator.
    - i. Treatments may be decreased when chest x-ray is clear and patient has minimal secretions.
10. Other tests.
  - a. Chest x-ray.
  - b. FVC.
  - c. Sputum culture within 2 hours if admitted.
  - d. ABGs after 1 hour of being placed on bedside ventilator.
- II. Limits to be used within ventilator protocol.
  - A. Peak pressures not to exceed 40cm/H<sub>2</sub>O.
    1. If peak pressure increases to a maximum of 40cm/H<sub>2</sub>O with any tidal volume or peak flow change, go back to previous settings and notify the physician.
    2. If at any time the peak pressure measures greater than 40cm/H<sub>2</sub>O, decrease tidal volume by 100cc, then peak flow by 10L/M, until pressures remain below 40cm/H<sub>2</sub>O. Then draw ABGs and call the physician.

- B. Tidal volumes no greater than:
1. 25cc/kg ideal body weight.
  2. 20cc/kg ideal body weight.
  3. On rare occasions tidal volume may exceed the 20–25cc/kg limits, but must be ordered by the physician.
- C. If the chest x-ray is clear and the patient has minimal secretions and is afebrile, respiratory therapists may stop increasing tidal volume (ventilator protocol patients only).
- D. Peak flow not to exceed 120L/M.
- E. If tidal volume exceeds 25cc/kg of ideal body weight, respiratory therapists must inform the physician.
- F. If the patient complains of gastric distension, the respiratory therapist will check with the physician about the possibility of decreasing the tidal volume.
- G. The physician should be contacted if the patient complains of discomfort, chest pain, or shortness of breath.
- III. Calculations to be used for patients on a portable ventilator:
- A. If a patient is placed on a portable ventilator and the VT/O<sub>2</sub> lpm are greater than or equal to 30cc/kg, the respiratory therapist must calculate additional volume and percent of O<sub>2</sub> from added O<sub>2</sub> that is bled in. The volume plus bled-in tidal volume equals ordered tidal volume. These formulas are as shown in the example below.
- IV. Ventilator protocol patients only: Day 2 and thereafter.
- A. The patient is evaluated daily for the following steps in the protocol.
1. If peak pressure is under 40cm/H<sub>2</sub>O, then VT is increased by 100cc per day.
  2. If peak pressure is still under 40cm/H<sub>2</sub>O after the increase in tidal column, then peak flow is increased by 10L/M per day. (NOTE: If patient is 66 inches or shorter, then only increase tidal volumes by 50cc and only increase peak flow by 5cc.)
  3. PEEP is decreased by 2cm per day until the PEEP is entirely removed.
  4. If O<sub>2</sub> saturation is greater than 92%, the FiO<sub>2</sub> may be decreased via titration to maintain SaO<sub>2</sub> of greater than 92%.
  5. EtCO<sub>2</sub> will be monitored via a capnograph during all ventilator changes to maintain EtCO<sub>2</sub> of 28–35mm/HG, by adding or subtracting appropriate dead space.
    - a. If patient has cuff deflations on the ventilator longer than one hour, capnograph and adjust dead space with cuff up and also with cuff down.
      - i. Document appropriate dead spaces for each.
      - ii. Therapist adds or subtracts dead space with cuff changes.
  6. Therapist documents ventilator protocol and lists current settings that reflect daily changes. These orders must be signed off by the physician within 24 hours.

**Example:**

The physician orders the patient to receive 1200cc tidal volume (VT) at 30% FiO<sub>2</sub> and a rate of 12bpm.

$$V_v = \frac{V_T(1 - FiO_2)}{.79}$$

Where: V<sub>v</sub> = Ventilator volume setting in cc  
 V<sub>T</sub> = Desired tidal volume  
 FiO<sub>2</sub> = Fraction of inspired O<sub>2</sub>

$$\text{Therefore: } \frac{V_v = 1200(1 - .3)}{.79} = 840 = \frac{1063\text{cc's VT vent setting}}{.79}$$

$$2. \quad O_2 \text{ flow to get 30\%} = \frac{(V_T - V_v) R}{1000}$$

Where: O<sub>2</sub> flow = lpm  
 V<sub>T</sub> = Desired patient tidal volume in cc's  
 V<sub>v</sub> = Ventilator tidal volume setting as determined above  
 R = Breath rate/minute

$$\text{Therefore: } O_2 \text{ flow} = \frac{(1200 - 1050) R}{1000} = \frac{1800 - 1.8}{1000} \text{ or (rounded to) } 2 \text{ lpm } O_2 \text{ flow}$$

# Appendix C:

## Wean Protocol for Ventilator-Dependent Quadriplegic Patients

The following protocol is a policy/procedure used by Craig Hospital, Englewood, Colorado (December 1996).

### Rationale:

To establish guidelines to be followed for weaning all ventilator protocol patients.

### Scope:

Respiratory care practitioners (RCPs) and other clinicians with demonstrated competencies.

### Policy Statement:

All patients who are placed on wean protocol by physician order shall be weaned according to the following criteria. Wean protocol may be ordered independently of other protocols.

### Procedure:

- I. Physician writes "Wean Protocol" after admission to hospital.
- II. Criteria to begin or to increase weans:
  - A. Chest x-ray is clear or improving.
  - B. Patient agrees to the procedure.
- III. Each change should be maintained for 1–3 days and may be increased under the following conditions:
  - A. Patient agrees to an increase.
  - B. Chest x-ray is clear or improving.
  - C. ABGs or pulse oximetry is within acceptable limits.
- IV. Schedule for weans: Respiratory care practitioners write wean protocol orders. Physician signs off on orders within 24 hours.
  - A. 2 minutes TID
  - 5 minutes TID

10 minutes TID  
 20 minutes TID  
 30 minutes TID  
 60 minutes TID  
 2 hours TID  
 3 hours BID  
 4 hours BID  
 8–10 hours QD  
 12 hours QD  
 14 hours QD  
 16 hours QD  
 18 hours QD  
 20 hours QD  
 22 hours QD  
 24 hours QD

- B. On the judgment of the RCP, a patient can have time increased a maximum of two steps at a time on the wean protocol schedule.
- V. Weans are to be done with cuff down and trach talk as tolerated. Titrate to >92%.
- VI. Weans may be discontinued or reduced in length of time if the patient has persistent atelectasis. Reasons for discontinuing or reducing the length of weans are to be documented in the progress notes and the physician is to be notified.
- VII. Discontinuing the ventilator.
  - A. RCPs may discontinue the wheelchair ventilator when patient is weaning greater than 14 hours per day.
  - B. RCPs may change bedside 7200 or Star to portable bedside ventilator when the patient ventilator parameters and ABGs are stable.
  - C. RCPs may discontinue bedside ventilator when the patient has been off for 48 hours and there is no sign of distress.

# Appendix D:

## Wean Discontinuation Protocol

The following protocol is a policy/procedure used by Craig Hospital, Englewood, Colorado (December 1996).

### Rationale:

To establish guidelines to be followed for discontinuing weans and required parameters during weans.

### Scope:

Respiratory care practitioners (RCPs) and all other clinicians with demonstrated competencies.

### Policy Statement:

The following criteria will be used for discontinuing weans of ventilator-dependent quadriplegic patients and required parameters for weans.

### Procedure:

- I. Two or more of the following criteria must be documented to discontinue weans:
  - A. RR increased to  $>35$ b/m.
  - B. HR increased by 20 from baseline or is  $>130$ /minute or  $<60$ /minute.
  - C. BP change of plus or minus 30 points from baseline or systolic pressure  $<70$  or diastolic  $>100$ .
  - D.  $\text{SaO}_2 <92\%$  with an  $\text{FiO}_2$  increase of 20 TORR higher than ordered.
  - E. FVC  $<1/2$  of documented patient baseline.
  - F. Marked increase in spasms, diaphoresis, or change in mental status.
  - G. Marked increase of complaint of shortness of breath or fatigue. \*May be an indication to discontinue wean or cuff deflations by itself on the judgment of the RCP.
  - H. Patient request.
- II. Required documented parameters for all weans:
  - A. FVC—forced vital capacity.
  - B. TV—tidal volume.
  - C. RR—respiratory rate.
  - D. HR—heart rate.
  - E.  $\text{SaO}_2$ —per RCPs discretion—oxygen saturation.
  - F. NIF—negative inspiratory force.
  - G. V—minute ventilation.
- III. All weans of 5 minutes or less are required to have at least 1 set of parameters (FVC, NIF).
- IV. All weans of greater than 5 minutes are required to have pre- and post-FVCs and if patient is able, NIFs as tolerated.
- V. RCPs are to stop each wean if wean discontinuation criteria are met and may totally discontinue weans if problems continue for three consecutive times.
- VI. RCPs are to document reasons for discontinuing the weans in the progress notes and notify the physician.

# Appendix E: Cuff Deflation Protocol for Ventilator-Dependent Quadriplegic Patients

The following protocol is a policy/procedure used by Craig Hospital, Englewood, Colorado (December 1996).

## Rationale:

To establish guidelines to be followed for cuff deflations for all ventilator protocol patients.

## Scope:

Respiratory care practitioners (RCPs) and all other clinicians with demonstrated competencies.

## Policy Statement:

The following criteria will be used for cuff deflations for patients who are participating in the ventilator protocol but may be ordered separately.

## Procedure:

- I. Physician writes "Cuff Deflation Protocol" when patient is admitted to hospital.
- II. Criteria to begin or increase cuff deflations:
  - A. No significant problem with aspiration.
  - B. Patient is already eating without problems.
  - C. Physician and speech therapist clearance note: May use minimal leak technique for those patients unable to swallow, if cleared by pulmonologist and physician.
  - D. Patient agrees to the procedure.
  - E. Chest x-ray is clear or improving.  
Exceptions: May try cuff deflations if patient has zero vital capacity and will never be weaned from the ventilator, but has minor atelectasis.
- III. Cuff deflations should be maintained for 1–3 days and may be increased under the following conditions.
  - A. Patient agrees to increase the cuff deflations.
  - B. Chest x-ray is clear or improving.
  - C. ABGs or pulse oximetry is within acceptable limits.
  - D. No clinical evidence of aspiration/laryngeal penetration.
- IV. Schedule for cuff deflations. RCP writes "Cuff Deflation Protocol" orders. Physician signs off on orders within 24 hours.
  - A. 2 minutes TID  
5 minutes TID  
10 minutes TID  
20 minutes TID  
30 minutes TID  
60 minutes TID  
2 hours TID  
3 hours BID  
4 hours BID  
8–10 hours QD  
12 hours QD  
14 hours QD  
16 hours QD  
18 hours QD  
20 hours QD  
22 hours QD  
24 hours QD
  - B. On the judgment of the RCP, a patient can have time increased a maximum of two steps at a time on the cuff deflation protocol schedule.
- V. Cuff deflations should be done with trach talk during weans as tolerated. Some patients may only be able to tolerate cuff deflations on the ventilator but not during the weans.
- VI. Therapist may increase tidal volume with cuff deflations from 100 to 400cc to improve patient tolerance and compensate for the leak.
- VII. Therapist may increase peak flow with cuff deflations for patient tolerance and compensate for the leak.
- VIII. All cuff deflations should be documented on wean sheets whether they are completed or not.
- IX. Cuff deflations may be discontinued or reduced in length of time if patient has either persistent



- atelectasis or has evidence of aspiration/laryngeal penetration (Cuff Deflation Discontinuation Policy). Reasons for discontinuing or reducing the length of time are to be documented in the progress notes and the physician is to be notified.
- X. Hold all cuff deflations if the patient complains of nausea or is vomiting.
  - XI. Changing to a Jackson Trach:
    - A. RCPs can change the patient to a Jackson Trach upon physician's order after the cuff has been continuously deflated for 48 hours and there is no sign of distress.
    - B. The Jackson Trach can be 1–2 sizes smaller than the existing plastic trach, after discussing with the physician.
    - C. RCPs can cap trachs and titrate O<sub>2</sub> to >92% via TTO on weaning patients, if Jackson Trach is a size 6 or smaller.
    - D. See policy and procedure manual for TTO per hospital and aerosol procedures.

# Appendix F: Cuff Deflation Discontinuation Protocol

The following protocol is a policy/procedure used by Craig Hospital, Englewood, Colorado (December 1996).

## Rationale:

To establish guidelines and required parameters to be followed for cuff deflations.

## Scope:

Respiratory care practitioners (RCPs) and all other clinicians with demonstrated competencies.

## Policy Statement:

The following criteria will be used for discontinuing cuff deflations of ventilator-dependent quadriplegic patients and required parameters for all cuff deflations.

## Procedure:

- I. Two or more of the following criteria must be documented to discontinue cuff deflations.
  - A. RR increased to  $>35$ b/m.
  - B. HR increased by 20 baseline or is  $>130$ /minute or  $<60$ /minute.
  - C. BP change of plus or minus 30 points from baseline or systolic pressure  $<70$  or diastolic  $>100$ .
- II. RCPs may stop each cuff deflation if criteria are met and may totally discontinue cuff deflations if problems continue for three consecutive times.
  - A. Discontinue cuff deflations if the patient complains of nausea, vomiting, or gastric distension.
  - B. In these cases, the decision to restart cuff deflations will be up to the physician.
- III. RCPs are to document the reasons for discontinuing cuff deflation in the progress notes and notify the physician.
  - D.  $\text{SaO}_2 < 92\%$  with an  $\text{FiO}_2$  increase of 20 TORR higher than ordered.
  - E.  $\text{FVC} < 1/2$  of documented patient baseline.
  - F. Marked increase in spasms, diaphoresis, or change in mental status.
  - G. Marked increase in complaints of shortness of breath or fatigue. \*May be an indication to discontinue cuff deflations by itself on the judgment of the RCP.
  - H. Patient requests.

# Appendix G:

## High Cuff Pressures Protocol

The following protocol is a policy/procedure used by Craig Hospital, Englewood, Colorado (November 1996).

**Rationale:**

To establish guidelines to be followed for high cuff pressures.

**Scope:**

Respiratory therapists.

**Policy Statement:**

Protocol for use if the patient's cuff requires greater than 40 H<sub>2</sub>O cm to achieve complete occlusion of the trachea (no air leak).

**Procedure:**

I. Chest x-ray—check for deformed cuff.

II. Add or subtract dressings under the flange on the trach tube to change the position of the cuff in the trachea.

III. Try using a minimal leak if tolerated by the patient. Note: Aspiration may occur.

With Physician Order

I. If possible, insert a larger size tracheostomy tube. Use bronch with E-T tube to position the E-T tube in the trachea and measure for special size or design trach.

II. Bivona or special order trach of special size or design.

# Appendix H: Post-Tracheoplasty/ Post-Extubation Protocol

The following protocol is a policy/procedure used by Craig Hospital, Englewood, Colorado (undated).

## Rationale:

To establish guidelines for the management of post-tracheoplasty/extubation patients.

## Scope:

Respiratory therapists and all other clinicians with demonstrated competencies.

## Policy Statement:

The following criteria will be used for all post-tracheoplasty and post-extubation patients.

## Procedure:

- I. Pulmonologist is to be advised as soon as the patient returns from surgery.

- II. Chest x-ray is ordered for all post-tracheoplasty patients to rule out atelectasis.
- III. Stretch IPPB instituted with 0.5cc Albuterol and 20mg Cromolyn sodium every 4 hours.
- IV. Quad cough as needed.
- V. Titrate O<sub>2</sub> to 92%.
  - A. Every 6 hours and prn for 24 hours.
  - B. Every 12 hours and prn for 48 hours.
  - C. Daily for 2 days.
- VI. If excessive bleeding occurs, consider DDAVP, with physician's order, 20mcq IV.
- VII. Use CPAP or BiPAP with physician's order if atelectasis is documented.

# Appendix I: Criteria for Decannulation of Trach Patients

The following protocol is a policy/procedure used by Craig Hospital, Englewood, Colorado (undated).

## Rationale:

To establish guidelines and criteria for the decannulation of trach patients.

## Scope:

Respiratory therapists.

## Policy Statement:

The following criteria will be used when evaluating a patient for decannulation.

## Procedure:

- I. The physician writes an order for respiratory therapy to evaluate a patient for decannulation.
- II. A copy of the criteria is placed in the patient's chart until completed and then removed and placed in the respiratory department file.
- III. Each respiratory therapist treating the patient in the following 24-hour period evaluates the patient for decannulation using the following criteria.

## Criteria for Decannulation

• Negative sputum culture	Yes	No	NA
• Clear CXR	Yes	No	NA
• Mobile, out of bed	Yes	No	NA
• No pending procedures	Yes	No	NA
• Not pressed to extubate	Yes	No	NA
• No aspiration problem	Yes	No	NA
FVC >15cc/kg ideal body weight	Yes	No	NA
Sat's $\geq$ 92% on room air	Yes	No	NA
Suctioning $\leq$ 3 times/day	Yes	No	NA
Effective quad cough	Yes	No	NA
Afebrile X3 days	Yes	No	NA
Stable X24 hours	Yes	No	NA
Three shift evaluations by therapists	Yes	No	NA

- Should have 5 of 6 of these.

## After Extubation:

Stretch IPPB 1 week post decannulation with 0.5cc Albuterol x 20mg Cromolyn sodium.

Continued meds—Slow taper

Patient name: \_\_\_\_\_

Injury level: \_\_\_\_\_

Date: \_\_\_\_\_

## Respiratory Therapy:

Day shift: \_\_\_\_\_

Evening shift: \_\_\_\_\_

Night shift: \_\_\_\_\_

# Appendix J: Evaluation of High Peak Pressure on Mechanically Ventilated Patients

The following protocol is a policy/procedure used by Craig Hospital, Englewood, Colorado (undated).

CAUSE—Increased Airway Resistance	CORRECTION OR ACTION TO TAKE
Water in tubing	More frequent draining
Secretions or blood clot in or occluding tube	Suction first; if not better, bronchoscopy or change tube
Kinking in tube	Bite block, change tube
Narrow E-T tube	Change to larger diameter E-T tube
<ul style="list-style-type: none"> <li>• Decrease in compliance</li> <li>• Pneumothorax</li> <li>• ARDS</li> <li>• Atelectasis</li> <li>• Restrictive lung disease</li> </ul>	<ul style="list-style-type: none"> <li>• Improvement of lung problem</li> <li>• Check CXR (this is indicated if there is a large, dramatic, sudden change in pressure)</li> <li>• Check static compliance</li> </ul>
Interstitial edema	Diuresis (physician to order)
Bronchospasm (wheezing)	<ul style="list-style-type: none"> <li>• Beta II drugs</li> <li>• Steroids (physician to order)</li> <li>• Attovent (physician to order)</li> </ul>
<ul style="list-style-type: none"> <li>• Hygroscopic compressor</li> <li>• Humidifier (HCH) (humidity filter closest to patient's E-T tube)</li> </ul>	Change filter
CHANGE BOTH FILTERS AFTER ALL OTHER EVALUATIONS ARE MADE	
IF ALL ELSE FAILS, USE A NEW VENTILATOR WITH ALL NEW TUBING AND FILTERS	
BRONCHOSCOPY	
WHEN IN DOUBT, CHANGE IT OUT—DO NOT COMPROMISE PATIENT	
USE MANUAL RESUSCITATION BAG ON 100% FiO <sub>2</sub> WITH PEEP VALVE IF PATIENT IS ON PEEP, AND CALL FOR HELP	
If ventilator is changed out, DO NOT remove tubing as manufacturer may need to evaluate entire circuit and vent.	

# References

The following list of references includes all sources used by the guideline development panel to support their recommendations. It provides the level of scientific evidence (I–V or NA) for each graded article. A graded article is one that was evaluated by the methodologists to determine whether it met inclusion criteria established by the panel. If an article is labeled “Scientific Evidence–NA,” it was evaluated by the methodologists but did not meet the level of evidence criteria. If a citation is not labeled, it was not evaluated by the methodologists. Citations labeled NA or unlabeled are included because they were considered by the panel to enhance understanding of the guideline.

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# NOTES

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