WELCOME

September 3-6, 2023

RIDING THE WAVES OF
Excellence
in SCI Care

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Respiratory Management in SCI

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DISCLOSURE

None

LEARNING OBJECTIVES

At the conclusion of this presentation, the learner will:

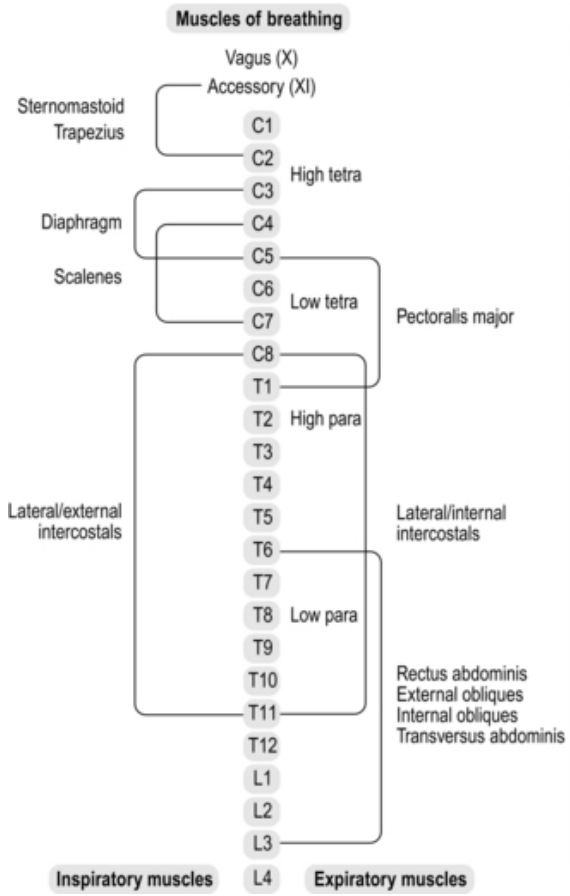
- Understand Restrictive pulmonary disease/respiratory impairment in the setting of spinal cord injury
- Understand the role of Invasive and noninvasive ventilation/MIE
- Identify respiratory complications including Infection/aspiration/atelectasis

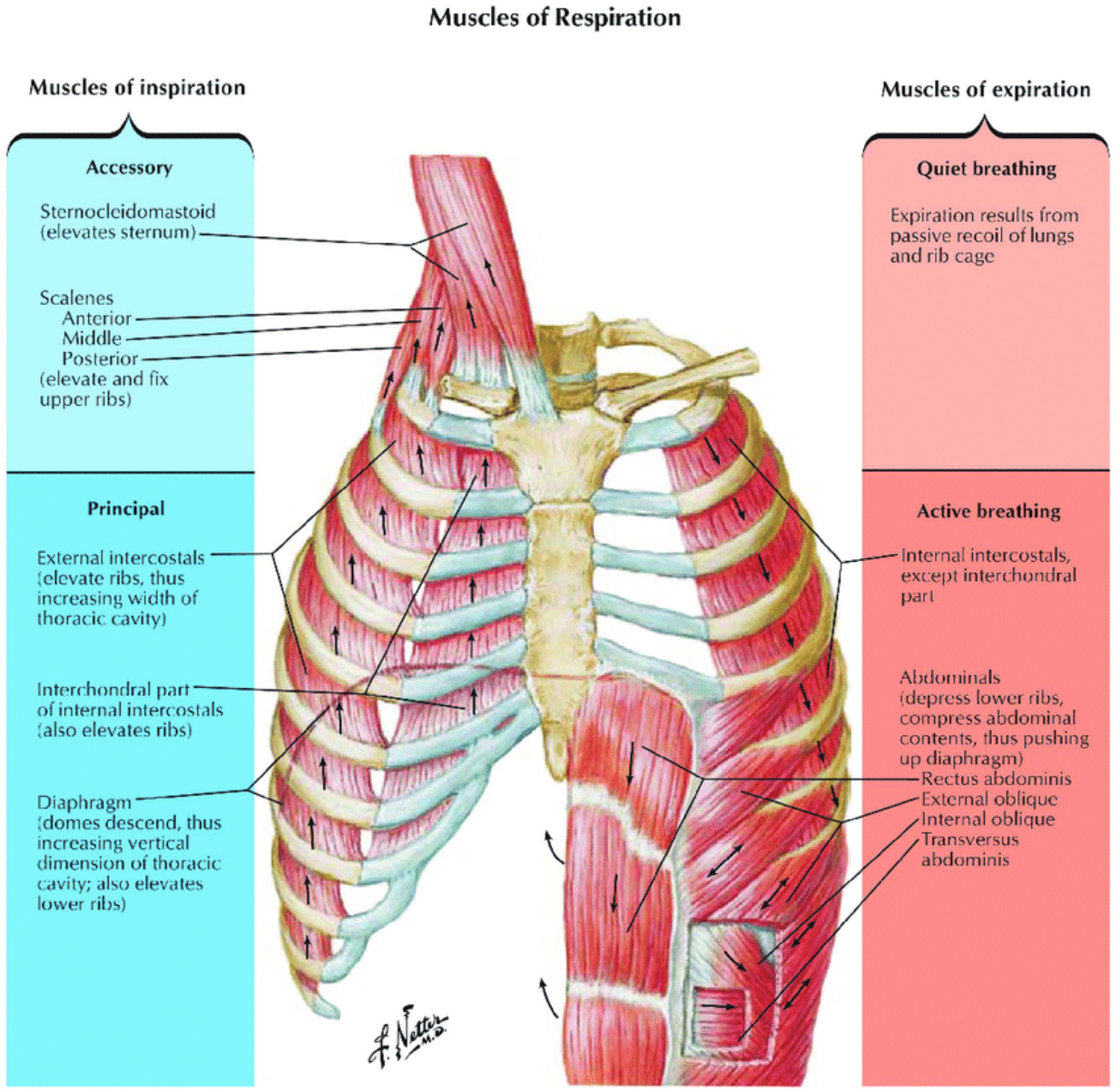
Introduction

- Respiratory complications are the leading cause of death in persons with spinal cord injury
- About 30% of all deaths after an SCI are due to respiratory causes, with pneumonia as the most common respiratory cause
- 2/3 of acute C1-T12 patients develop respiratory problems
- Little evidence based literature, current practice principles are based largely on expert panel opinion and clinical expertise.
- 3 key pulmonary problems in individuals with SCI
  - Secretion management
  - Atelectasis
  - Hypoventilation

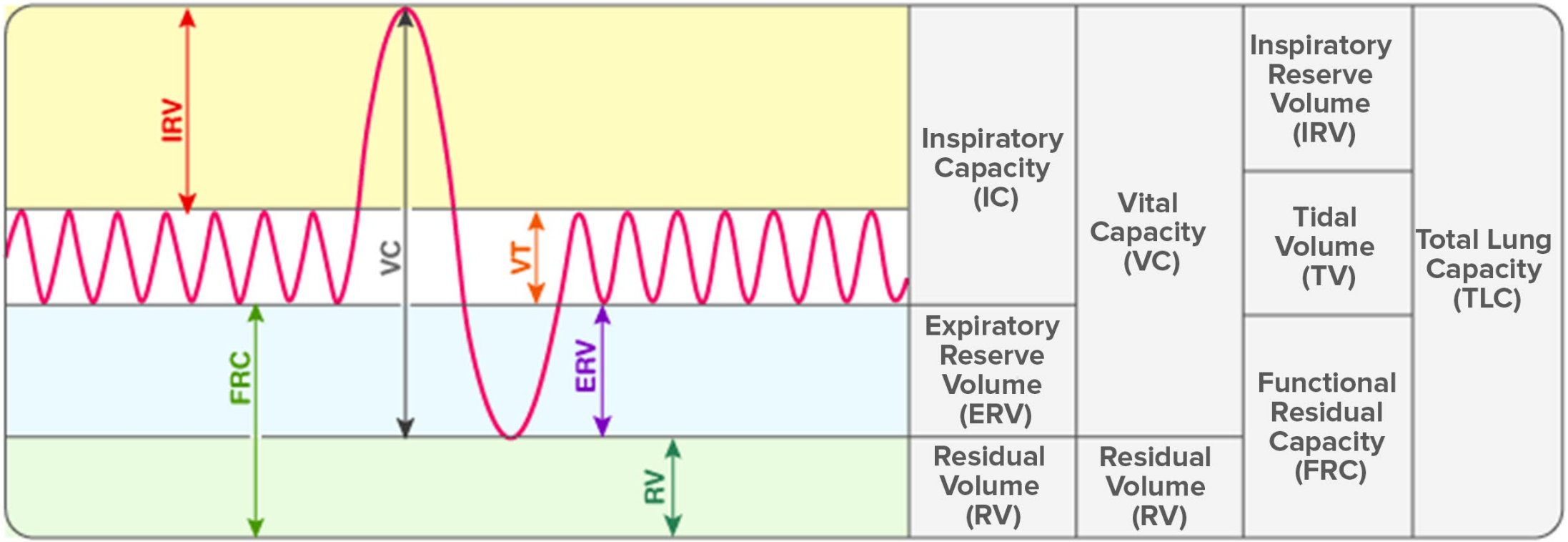
Anatomy

- Injury to cord at or above C5 causes impairment of diaphragmatic function (65% of VC)
- Accessory muscles least affected
- Expiration is passive, active contraction necessary for cough and secretion clearance
- Complete injury at T6 or above results in ineffective cough





LUNG'S VOLUMES AND CAPACITIES



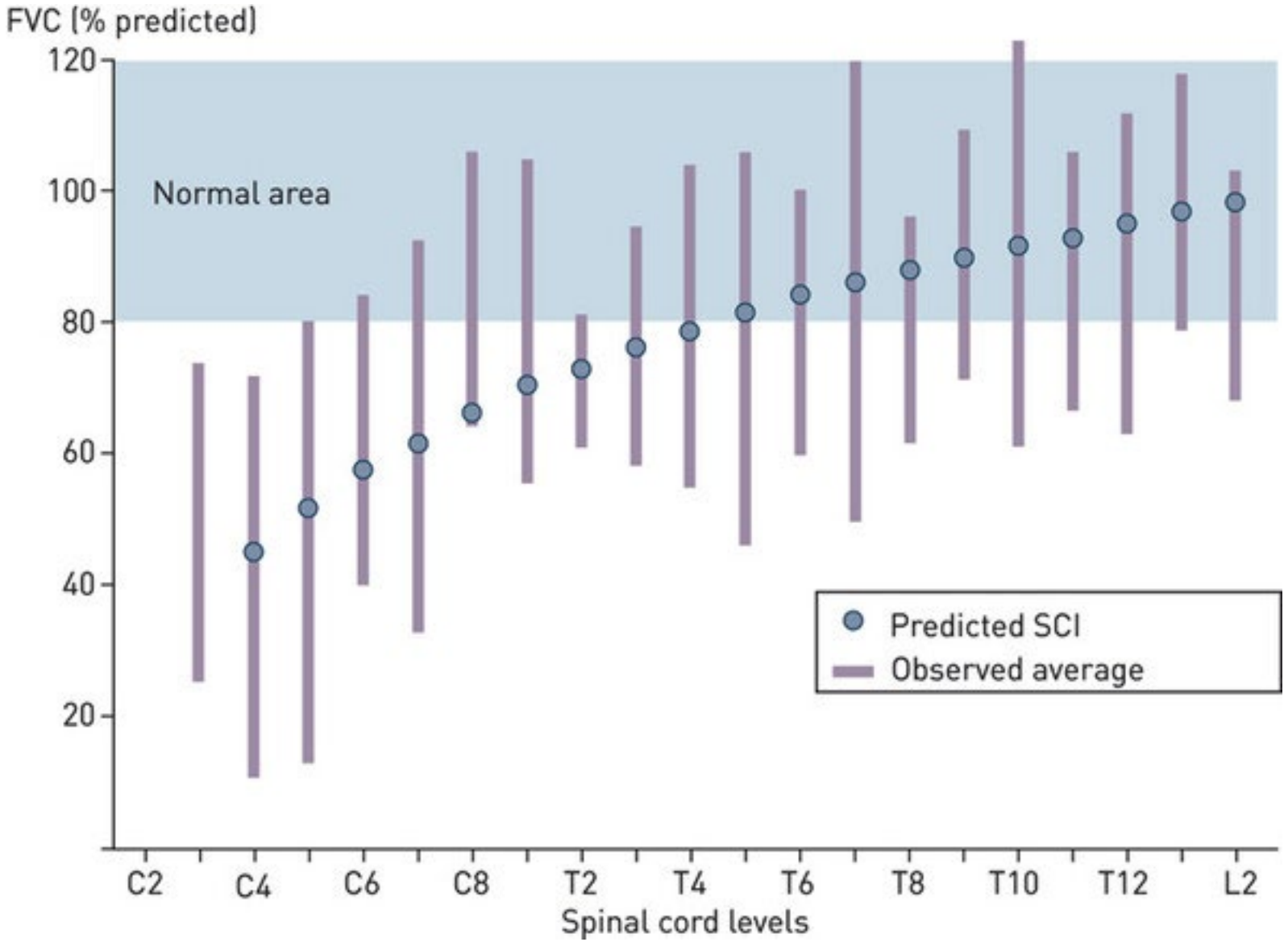


Figure 1 *Forced vital capacity in spinal cord injury at different levels. Adapted and based on Table 2 in Linn et al.*

Acute Injury

- Respiratory failure may develop within the first week of SCI
- Risk associated with level and completeness of injury
- Risk factors include:
  - Age >45 years
  - Pneumonia
  - Copious secretions
  - Associated trauma
  - Body habitus
  - Pre-existing cardiopulmonary disease
- Patients may lose up to one motor root level within the first few days post injury

Acute Injury

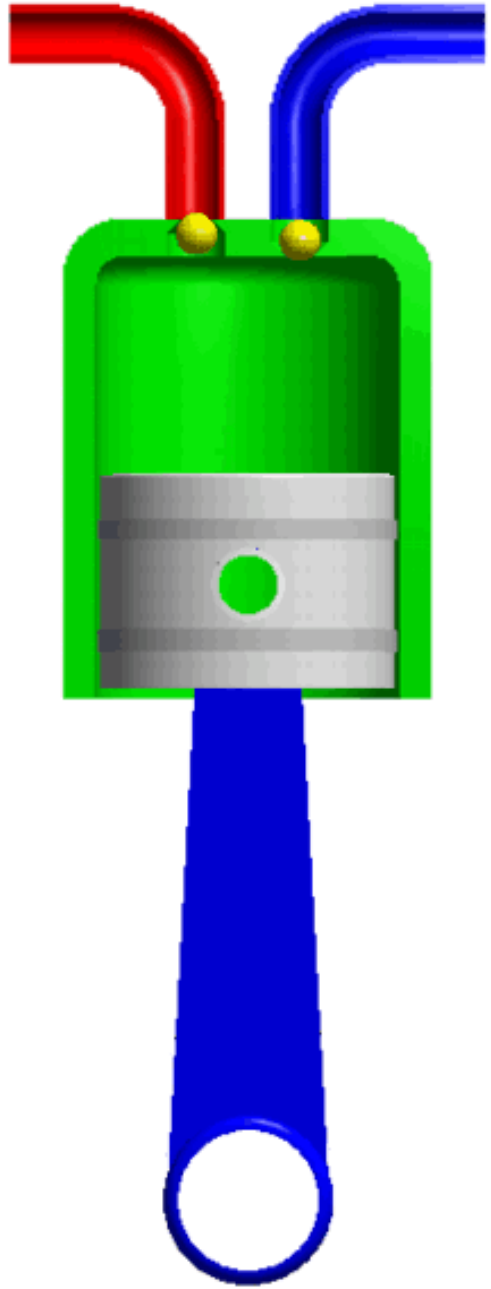
- Indications for tracheostomies
  - All with C3 level or greater
  - C5 level complete or higher injury with respiratory failure
  - C6 level complete or lower injury with respiratory failure 79%
  - C8 level and lower injury generally do not require tracheostomies

Pathophysiology

- Impaired cough; once peak cough flows fall to less than 160L/m, insufficient force
- When intercostal and abdominal musculature is flaccid, paradoxical movements result in a significant drop in the efficiency of breathing
- atelectasis is the most common respiratory complication
- Decreased inflation of the alveoli also leads to significant reduction in the release of surfactant
- Hypersecretion of bronchial mucus, abnormal both in amount and chemical content (thicker)
- Due to autonomic changes bronchospasm is routinely seen
    - when ipratropium by inhalation is used in individuals with tetraplegia, the forced VC increased significantly from 41% to 50%
- Chest trauma including rib fractures, flail chest, pulmonary contusions or laceration, avulsion of a bronchus, rupture of the diaphragm/esophagus, pneumothorax, hemothorax, and hemoperricardium will impact function


Inspiration
Normal
SCI Cervical


Expiration
Normal
SCI-Cervica



Lung Volume Changes

- Ventilatory patterns alter significantly during the first year of injury
- Immediately following injury, flaccid paralysis of the intercostal and abdominal muscles resulting reduction of vital capacity to approximately 20-60% of predicted value in tetraplegia and 80-90% in paraplegia
- Truncal and intercostal tone increases with time, stabilizing the rib cage and returning vital capacity to approximately 60% of the pre-injury level
- Progressive reduction in functional residual capacity due to atelectasis and basal pulmonary fibrosis
- Residual volume remains elevated compared with normal population values
- Total lung capacity does not recover significantly

Techniques of Diaphragmatic Assessment

- Observation
- Sniff test
- Sonography
- EMG
- Phrenic nerve conduction
- Transdiaphragmatic pressure

Respiratory Complications

- Incidence of atelectasis and/or pneumonia during inpatient rehabilitation has been estimated between 9.1 and 14.8% for individuals entering the model SCI systems program since 1996
- Ventilator associated pneumonia increases by 1% to 3% per day of intubation
- Cotton et all found that respiratory complications occurred in 51% of patients with T1-6 SCI versus 34.5% of T7-12 SCI.
- Diagnosis of pneumonia in patients with SCI is complicated by baseline prevalence of retained secretions.
- Aspiration pneumonia, initially with chemical pneumonitis then subsequently bacterial infection
- Risk factors for aspiration include tracheostomy, anterior spinal surgery, and mechanical ventilation

Pharmacological agents

- Beta agonists facilitate bronchodilation and mucus clearance
- inhaled corticosteroids may be used in combination with Beta agonist
- Several agents may be nebulized to assist in clearance of secretions
  - isotonic saline
  - sodium bicarbonate
  - acetylcysteine
- Anticholinergic agents increase FEV1
- Methylxanthines may improve diaphragmatic contractility

Treatment

- Positional Change Turning every 2 hours
- Rotation beds
- Chest percussion and drainage
- Suctioning
  - Give O2 for hypoxemia
  - Give atropine for bradycardia
- Assisted cough
- Bronchoscopy and bronchial lavage

Treatment

- Aggressive pulmonary toilet and lung expansion
  - Intermittent positive pressure breathing (IPPB)
  - Intrapulmonary percussive ventilation (IPV)
  - EzPAP
  - Ambu bag
  - Mechanical insufflator/exsufflator
  - High TV mechanical ventilation

Assessment

- Signs of impending respiratory failure include tachypnea, progressive desaturation, and decrease in VC to less than 15 ml/kg
- Arterial oxygen tension (PaO2) is the most sensitive tool for evaluation of atelectasis.
- Arterial carbon dioxide (PaCO2) tension is used to evaluate ventilation abnormalities.
- VC is the best predictor of muscle fatigue
- If VC approaches 10ml/kg immediate support is indicated
- Indications for intubation include increasing oxygen requirements, increasing respiratory rate, rising PCO2, and diminishing breath sounds
- Tracheostomy should should not be prolonged beyond 1-2 weeks
- Cuff pressures should be monitored and maintained below 25 cm H20

Ventilator Settings

- Generally ventilation with TV of 15 to 20 mL/Kg are routinely used in spinal cord population
- ARDSNet trial outline a significant increase in mortality in patients treated with high TV
  - Excluded patients with neuromuscular disease
- If pneumonia leads to any evidence of significant intrinsic lung injury, revert back to low lung volume models 6mL/kg
- Increases in volumes are held when peak pressures exceed 35 mm H20 or when plateau pressures exceed 25 mm H20

Criteria for Weaning

- NLI serves as a gross determinant of the weaning prognosis
- 80% of patients with injuries C4 and below successfully weaned
- 50% weaned at C3 level
- 28% with C2 level of injuries
- 0% of patients with C1 injuries
- Patients who achieved maximal NIF of >40 ml H20 and VC greater than 17 ml/kg body weight able to successfully wean
- Healthy lungs prior to wean; afebrile, hemodynamically stable
- minimal to no supplemental oxygen
- ABG values within normal limits

Electrical Stimulation

- Diaphragmatic pacing vs Phrenic nerve stimulation
- PNS requires thoracotomy for place of electrodes; DP can be done by laparoscopic approach
- Alternative to mechanical ventilation 24 hours per day
- Eligibility criteria include
  - highly motivated improve function
  - supportive caregiver
  - medical stability
  - appropriate patient/caregiver expectations
- Implanted at least 12 months post injury
- Evaluated with NCS and fluroroscopy

Glossopharyngeal Breathing

- involves rapidly taking small gulps using tongue and pharyngeal muscles to project the air past the glottis into the longs; 6-9 gulps of 60-200ml each
- useful in patients sho do nota have diaphragmatic strength
- requires intact midbrain
- technique to increase the VC, which allows for:
  - assistance in cough
  - improvement in audibility of patients voice,
  - ventilator free time

Sleep Apnea

- Sleep disordered breathing reported 15% to 62%, more prevalent in tetraplegia vs paraplegia.
- not usually apparent until 2 weeks post injury
- OSA is the predominant form
- Risk factors for SDB include:
  - increased neck circumference
  - individuals with SCI spending more time supine while asleep
  - increase in waist circumference
  - use of sedating medication
  - unopposed parasympathetic activation
  - higher level of SCI
  - obesity with BMI <30 kg/m2

Summary

- Cervical and high thoracic spinal cord injury results in reduction of vital capacity and increased residual volume impacting efficiency of respiratory system
- Aggressive pulmonary toileting and volume expansion are key to minimizing complications
- Supportive measures should be initiate early to prevent serious respiratory failure
- Respiratory function may be augmented with electrical stimulation of phrenic nerve or diaphragm
- Respiratory complications are the leading cause of death in persons with spinal cord injury

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THANK YOU!

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Q and A

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