Aerodigestive and Respiratory Changes Post Tracheostomy: A Comprehensive Review

Learning Objectives:
- Review anatomy & physiology of upper airway (aero-digestive system)
- Review anatomy & physiology of lower airway
- Understand the physiologic changes to the airway secondary to the tracheotomy, and relate these changes to specific disease processes
- Discuss complications of the tracheostomy tube

Upper Respiratory Tract
- Nasal Cavity
- Oral Cavity
- Pharynx
- Larynx
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Nasal Cavity
- Heats, humidifies, filters, resonates sound, and olfaction
- Velum elevates during the swallow, closes the nasal cavity, and prevents nasal regurgitation

Oral Cavity
Primary role is respiration, but is also used for swallow, digestion and speech
- Lips - seal oral cavity for swallow
- Tongue - oral prep, oral transit (base of tongue is the primary muscle used to propel food - it rests on hyoid bone)
- Salivary Glands - secrete lubrication

Pharynx
- Muscular tube that is dual passageway for respiration and swallow
- The 3 segments are:
  - Nasopharynx
  - Oropharynx
    - gag reflex
    - 13% no gag-not predictor of dysphagia
  - Laryngopharynx - separates digestive and respiratory tracts
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**Pharynx**
- **Vallecula**
  - recess between base of tongue and epiglottis
  - common landmark during intubation
- **Pharyngeal Muscles**
  - suspended from hyoid bone for laryngeal elevation and anterior motion
- **Epiglottis**
  - separates the respiratory and digestive system for airway protection
  - acts like a rudder to deflect food laterally away from the airway

**Larynx**
- **Cricoid Cartilage**
- **Thyroid Cartilage** (Adam's Apple)
- **Arytenoid Cartilages**
  - along with muscles, responsible for opening and closing vocal cords

**Larynx**
- Larynx is the “gatekeeper” to prevent aspiration at multiple levels
  - Pharyngeal Muscles - muscles attached to hyoid elevate larynx up and pull it forward
  - Laryngeal Muscles - close larynx at vocal fold level to create a seal that separates airway from digestive tract
Esophagus
- Muscular organ for swallow
  - peristalsis
- Cricopharyngeal Sphincter or Upper Esophageal Sphincter
  - muscular band that relaxes to allow food to enter esophagus when larynx elevates & pulls forward, and pressures change.

Aerodigestive Tract Is a Shared System
- Respiratory system shares a common functional space with the digestive tract and the vocal tract. The trachea is a dynamic structure. We never fully exhale (physiologic PEEP).

Upper Aerodigestive Tract Is a Valving System
- Beginning at the lips and ending at the UES, the valves are always permitting or preventing airflow, food, or liquids from going one direction or the other.
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Pressures
- Pressure becomes positive subglottically
  - Elastic recoil of lungs during apneic phase of swallow against a closed glottis
- Pressure becomes negative in the esophagus
  - Diameter of esophagus increases, pressure decreases (Boyle’s Law)

Shared Responsibility
- “These many pressure changes within the aerodigestive tract (shared passageway for respiration and swallow) protect the airway, & speed the food bolus. Literature supports the importance of coordinating breathing and swallowing.”

Role of Expiratory Airflow
- “Expiratory airflow is important to clear the airway by removing residual material that may be pooled in the pharynx and larynx. Resumed airflow s/p swallow serves to “sweep” the pharynx/larynx free of residual material.”
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Lower Respiratory Tract

- Trachea
- Bronchi
  - right and left mainstem
- Bronchioles
- Alveoli - air sacks
  - lined with surfactant, filled with air to prevent collapse/atelectasis

Lower Respiratory Tract

- Lungs
  - fill the thorax
  - highly elastic properties-elastic recoil
- Cradled in Pleura
  - Visceral Pleura
    - covers the lung surface
  - Parietal Pleura
    - lines the chest wall
    - Pleural fluid is lubricant, maintains a negative pressure that holds lungs open (opposes the elastic recoil)
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Muscles of Respiration

Respiratory Muscles - **Exhalation**
- Abdominal
- Oblique

Muscles of Respiration

Respiratory Muscles - **Inhalation**
- Diaphragm (phrenic nerve at C3, 4, and 5)
- Inter costals
- Pectoralis major and minor
- Strap muscles of neck
- Sternocleidomastoid
- Scalene muscles

Neurophysiology

**Cranial Nerves** – phonation

**Vagus Nerve**
- vocal fold movement,
- laryngeal sensation
- speech and swallow function
- often damaged in cardiac or thyroid surgeries
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Neurophysiology of Breathing

Respiratory Control Center
- Brainstem
  - Medulla Oblongata
  - Pons

Chemoreceptors
- CO₂ and O₂ levels define inspiration and respiratory drive

Stretch Receptors
- Define exhalation

Diseases

Obstructive Disorders
COPD - (chronic obstructive pulmonary disease)
- Irreversible airway obstruction
- Caused by damaged lung tissue

Chronic Bronchitis
- Chronic cough, mucus production, narrow airways secondary to irritation
- Bronchospasm

Emphysema
- Deterioration in alveolar walls
- Loss of elastic recoil
- Flat diaphragm

Restrictive Disorders
- Reduced lung volumes
- Decreased compliance (stiff lungs)
- Inability to take deep breaths

- Connective Tissue Disorders - fibrotic changes, scleroderma, lupus, pulmonary fibrosis

- Thoracic deformities - reduced volumes, scoliosis, kyphosis, rib fractures

- Pneumonia - infection and inflammation (bacterial, viral or aspiration)
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Restrictive versus Obstructive

Neuromuscular Disorders
- Degenerative Diseases that affect respiratory muscles
  - ALS
  - Guillain-Barré
  - Polio
  - Spinal Cord Injury
  - MD
  - MS

 Diseases
- Cardiopulmonary Conditions - poor circulation of blood to lungs/body "cardiac cripple"
  - Right Heart Failure
    - dependent edema
  - Left Heart
    - CHF
  - Both Sides
    - total failure
Diseases

ARDS
- Adult respiratory distress syndrome
  - Damage to alveolar-capillary membrane resulting in severe impairment of gas exchange (fibrotic changes may be permanent)
- Multi-factorial
  - Stroke, trauma, infection, sepsis, severe pneumonia, inhalation injury, etc.

Clinical Complications of Tracheostomy

Proper Cuff Inflation
Cuff Over-Inflation

- Esophageal impingement
- Reflux
- Necrosis and Trauma

Measure Cuff Pressures

Complications of Cuffs

- Inflated cuffs can tether larynx
  - Larynx does not elevate
  - Epiglottis does project down to protect airway
  - Larynx does not move anteriorly
  - Esophagus does not increase its diameter, creating the vacuum environment for food bolus transition
Tracheostomy and Aspiration

• Does a cuff prevent aspiration?
• Definition
• Incidence of aspiration
  – 50% - 87% rate for trach and vent patients\(^1\)
  – 75% silent aspiration\(^2\)
  – Aspiration around the cuff\(^3\)

1. Elpern et al., 1987, 1994, 2000; Tolep et al., 1996
2. Davis & Stanton, 2004; Elpern et al., 1994
3. Bone, Davis, Zuidema, & Cameron, 1974; Elpern et al., 1987; Nash, 1988; Pavlin, VanNimwegan, & Hombein, 1975; Ross & White, 2003

Clinical Complications

• Lack of vocal production—communication
• Psychological—agon, fear, panic, frustration
• Decreased sense of smell/taste

Clinical Complications

• Removal of natural filtration and humidification system
• Cycle of irritation and secretion production
Clinical Complications

- Decreased Sensation in the Oropharynx
- Reduced Airway Closure
- Reduced Subglottic Air Pressure

Clinical Complications

- Lack of subglottic pressure
  - Decreased swallow efficiency
  - Increased risk of aspiration - poor vocal fold closure
  - Feeding tube is inevitable

Clinical Complications

- Decreased effectiveness of cough
  - Patient is unable to mobilize secretion
  - Patient requires frequent tracheal suction and oral care
Complications of Tracheostomy

- Decreased physiologic PEEP (positive end expiratory pressure)
  - Decreased gas exchange due
  - to less surface area (2 to atelectasis)
  - Decreased oxygenation
  - Possible atelectasis

Complications of Tracheostomy

- Inability to valsalva
  - balance and equilibrium
  - examples
    - ADL's
    - Transfers
    - Toileting
    - Exercise

What Happens When a Passy-Muir® Valve Is Applied?
Clinical Benefits

- Restoration of voice and communication
- 100% airflow through vocal tract on exhalation provides superior vocal quality
- Improved sense of smell and taste
- Eliminates finger occlusion and chin dropping

Physiologic Benefits

- Improves Swallowing
- Reduces Laryngeal Tethering
- Restores Positive Subglottic Pressure
- Restores Upper Airway Airflow/Sensation

Improves Swallowing

- Laryngeal Elevation
- Improved Sensation
- Vocal Cord Closure
- Restored Subglottic Pressure

Dettelbach et al., 1995; Stachler et al., 1996; Elpern et al., 2000; Suiter et al., 2003; Gross et al., 2003

Reduced Aspiration
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**Restores physiological PEEP**
- Improved gas exchange
- Improved oxygen saturation levels
- Decreased risk of atelectasis

**Expedites Weaning and Decannulation**
- Rehabilitation tool for respiratory muscles
- Rehab tool for upper airway muscles
- Reduces decannulation time
- Easier to tolerate than capping/corking
- Develops confidence and motivation

**Cost Savings**
- Tube Feeding
- Antibiotics/ICU stay
- Vent days/LOS
- Suctioning Supplies

About $1 a day
- Passy-Muir Valve

HCUPE 2006 statistics

Frey and Wood, 1995

Frey & Wood, 1991; Sierros, et. al. 2007; Light et al., 1989
Quality of Life...

PRICELESS!!!

• Thank You!!
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