**PULMONARY REHABILITATION & USE OF HEAT AND MOISTURE EXCHANGERS (HME)**

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**Disclosures**

- Julie Bishop Leone is the Director of Clinical Education at Atos Medical Inc.
- Financial relationship disclosure: She is employed by Atos Medical Inc.
- They have no relevant nonfinancial relationships to disclose.

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**Purpose of the Respiratory System**

- Rapid Gas Exchange
  - Oxygen into the blood
  - Removal of Carbon Dioxide
- Well Coordinated interaction
  - Lungs
  - Central Nervous System
  - Diaphragm
  - Chest Wall Musculature
  - Circulatory System
Most Defense Mechanisms Exist in Upper Respiratory Tract

- Cilia trap large pieces of debris (>4mm) and push them out of the airways;
- Mucus attracts and traps smaller microorganisms and particles and keeps tract moist;
- The reflexes of sneezing and coughing help to expel particles from the respiratory system.

Defense Mechanisms Exist in Upper Airway:

- During nose breathing
  - Nostrils filter, warm & moisturize the air
  - Cilia push mucus back towards the pharynx to be swallowed
- During “Face Breathing”
  - Most debris is trapped in the nose and pharynx, not the trachea.

Goblet Cells

- Secrete mucus
- Basal secretion (low level, continuous, unregulated)
- Stimulated secretion: regulated in response to extracellular stimuli
- Mucus in goblet cell granules
  - Is condensed
  - When secreted in response to stimuli, expands in volume dramatically and almost at once (pressurized whipped cream)
- Increased numbers of goblet cells observed in several disease states: Chronic Bronchitis, COPD, emphysema

- Rogers DF: Airway goblet cells: responsive and adaptable front line defenders. Europ Respiratory J 7: S955, 1997; Eisen PD, Chert MA
Facts about Mucus

- Protective
- Sticky which helps to trap dust particles, bacteria and other inhaled debris.
- The respiratory tract produce about two liters of mucus a day from these glands (Martini, 2003).
- Mucus contains high H20 content which helps to humidify the passing inspired air.
- Mucus is a complex mixture of water, carbohydrates, proteins and lipids glycoproteins (or mucins) as well as proteins derived from plasma, and products of cell death such as DNA.
- Mucus contains lysozyme, which is an antibacterial enzyme.

Factors that Increase Mucus Production & Can Cause Mucosal Damage:

- Inhaled Irritants
  - Bacteria
  - Viruses
  - Volatiles
  - Dust
  - Pollens
  - Smoke
- Dehydration
- Infections
- Excessive Caffeine or Alcohol Intake

Visible changes due to chronic irritation

- Changes in Mucus
  - Color
  - Quantity
  - Consistency
  - Blood Streaks
  - Odor
  - Casts, Crusts, Plugs Casings
- Excessive Coughing
- Dry/Dehydrated Tracheal & Tracheobronchial Mucosa
- Point of optimal humidity shifts further into the peripheral of the lungs.
MUCUS PLUGS

- Occur when bronchial secretions accumulate to the point that they obstruct the airway
- Increased risk following TL/tracheostomy
- Patient can not always cough them up
- If airway is blocked, patient safety is at risk

After Surgery, Defense Mechanisms Have Been Compromised:

- Air is no longer humidified
- Temperature is not modulated
- Filtering is reduced
- Increased risk of mucus plugs
- Complaints of mucus production
- Coughing
- Decreased QOL

Laryngectomy vs. Tracheostomy
**Respiratory Physiology of the Neck Breather**

- At The Trachea
  - Air Temp = 72°F
  - RH=45%
  - Ambient Dirty

**KEY POINTS:**
- Ciliary activity impaired when RH drops below 70%
- Ciliary activity ceases when RH <50% RH at 37°C

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**Impact of SURGERY on the Defense Mechanisms in Upper Respiratory Tract**

- Cilia
  - Activity is dependent on RH and temperature
  - RH & temperature in trachea decrease after surgery
  - Ciliary activity ceases when RH reaches about <50%

- Goblet Cells
  - Hypersecrete in response to irritants i.e. dust, smoke, cold air, dryness and bacteria
  - Hypersecretory state is similar to whipped cream

- Coughing
  - expels particles from the respiratory system

- Complaints:
  - Excessive coughing, excessive sputum production, mucus plugs, crusting, & shortness of breath.

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**THE answer: Heat & Moisture Exchanger (HME)**

- Antimicrobial, hygroscopic properties
- Hygroscopic core increases moisture retention
- Water vapor condenses during exhalation & rehumidifies during inspiration
- Pulmonary heat & moisture (humidity) are retained
- Logical barrier to gross airborne matter
- HMEs cannot be rinsed out and reused
- An HME should never be used beyond 24 hours
**Effects on Breathing for neck breathers**

- Lost functions of the upper airway
  - Heating
  - Filtering
  - Humidity
  - Pulmonary resistance

**Effect of HME use on Lung Function in Laryngectomee**

- Compared HME to Non-HME users over 4-9 months
- Tracheal Biopsy performed and showed:
  - HME users had significantly more ciliated cells
  - Speed of mucus expectoration was greater in HME user
- Long term use of an HME restores/prevents the loss of tracheal ciliated cells.

**Mucus & QOL**

- N=59 TL
- Incidence & Severity of Respiratory Symptoms
  - 98% primary complaint = daily sputum production
  - 64% c/o excessive coughing
  - 57% c/o need for freq. forced expectoration (>5x/day)
  - 37% c/o freq. stoma cleaning (>5x/day)
- A significant correlation was found between respiratory symptoms, voice rehabilitation and several aspects of daily living, including fatigue, sleep problems, social contacts and psychological distress.
- Significant reductions were found in the mean daily frequency of sputum production, stoma cleaning and forced expectoration.
- Consequently several aspects of daily life, e.g. feelings of fatigue and malaise and sleeping problems, improved.
- The use of the HME also influenced the voice quality in a positive way as 50% of the patient’s perceived their voice to be louder and more clear.

References:
- Ackerstaff, Souren, van Zandwijk, Balm, Hilgers. Laryngoscope 1993;103:1391-4
All nurses had a preference for the HME System.

<table>
<thead>
<tr>
<th>Primary patient and nursing-related outcome measures</th>
<th>External Humidifier (N=16)</th>
<th>Heat and Moisture Exchanger (N=23)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compliance#</td>
<td>11 (42%)</td>
<td>23 (100%)</td>
</tr>
<tr>
<td>Used daily#</td>
<td>3 (12%)</td>
<td>20 (87%)</td>
</tr>
<tr>
<td>Coughing#</td>
<td>1 – 5/day</td>
<td>14 (58%)</td>
</tr>
<tr>
<td>Cough intensity</td>
<td>6 – 10/day</td>
<td>21 (90%)</td>
</tr>
<tr>
<td>1–5 cough/day</td>
<td>6 (25%)</td>
<td>2 (10%)</td>
</tr>
<tr>
<td>Mean daily frequency</td>
<td>5.6</td>
<td>2.5</td>
</tr>
<tr>
<td>Range</td>
<td>0 – 15</td>
<td>0 – 3</td>
</tr>
<tr>
<td>Breathing problems</td>
<td>20 (77%)</td>
<td>4 (17%)</td>
</tr>
<tr>
<td>Satisfied#</td>
<td>Not favorable</td>
<td>21 (85%)</td>
</tr>
<tr>
<td>A little favorable</td>
<td>2 (8%)</td>
<td>3 (13%)</td>
</tr>
<tr>
<td>Favorable</td>
<td>3 (11%)</td>
<td>22 (100%)</td>
</tr>
<tr>
<td>Nursing time involved in patient care**</td>
<td>50 minutes/day</td>
<td>20 minutes/day</td>
</tr>
</tbody>
</table>

**All nurses had a preference for the HME System.

Cost Comparison External Humidification versus Heat Moisture Exchanger (per day)

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<tr>
<td><strong>Dollars</strong></td>
</tr>
<tr>
<td>External Humidifier</td>
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<tr>
<td>Heat and Moisture Exchanger</td>
</tr>
</tbody>
</table>

Immediate Postoperative Use of an HME Results in...

- Easy adaptation & compliance
- Decreased need for suctioning (Chapman et al, 2014; Icuspit et al, 2014)
- Easier & faster care
- Cost-effective
- Eliminate & reduce moist air
- Immediate HME benefits
- Avoid mucus plugging
- Early familiarization, confidence & competence with stomal care and management (Chapman et al, 2014)
- Preparation for ambulatory care
- Easier to differentiate trach vs. laryngectomy
- Reduced stomal crusting and better handling of secretions (Icuspit et al, 2014)
- Easier discharge planning
- May decrease need for other medical supplies (i.e. moist air) and actually result in lower medical expenses (Brook et al, 2013)
**HME Systems**

- PROVX XTRAHME
- CYRANOSE
- INHEALTH
- LARYVOX

**Provox® HME Cassette Family**

- XtraHME™
- XtraFlow™
- XtraMoist™
- Micron™ HME
- Provox Luna™
- FreeHands HME® or with Titanium Cap
  - XtraFlow™
  - XtraMoist™

**Provox® Micron™ HME:**

- The Only True Filter for a Laryngectomee

  - Electrostatic filter
  - ≥99.8 BFE and VFE (bacterial and viral filtration efficacy)
  - HME breathing resistance is the same as the XtraFlow HME
  - Finger depression for TE speech
  - Good for 24hrs once exposed to air
  - Designed to wear in special circumstances (i.e. travel, flu/virus seasons, public exposure, dusty/dirty work etc.)
Provox® Micron™ HME
How it Works

Electrostatic filter material
(attracts charged particles)

Micron in Action

Soft and smooth for nighttime comfort
Low breathing resistance for easy breathing at night*
Superior humidification to other HMEs*
Side openings designed to prevent occlusion while sleeping

* data on file.
These are NOT HME's

Select an HME Based On:
- The evidence
- Pt. tolerance of airflow resistance
- Humidification requirements
- Environmental considerations
  - Public exposure
  - Climate
  - Air travel
  - Allergies
  - Environment
  - Physical activity
- Manual dexterity
- FlexiVoice (Hands Free) user?

Comparison of Core Material of Various HMEs

Conclusion (paraphrasing George Orwell’s “Animal Farm”): “All HMEs are equal, but some HMEs are more equal than others.”

Clinical Evidence per Manufacturer based on 75 articles published between 1990 and 2015, including all publications that discuss HME results.

HME Basics:
- Introduce the HME immediately postop
- The transition may be easier the sooner the HME is introduced
- Patient may require adaptation to HME resistance
- Amount of mucus/coughing may increase during the first days/weeks of use (thinning effect)
- Expected improvement in pulmonary function usually takes time (average 2-4 weeks)
- HMEs cannot be rinsed out and reused
- HMEs can provide easier and more hygienic stomal occlusion with most users
Peristomal Attachments
- Attachment to skin around stoma
- Base plates, valve housings, custom housings, tapes, glues/adhesives

Intraluminal Attachments
- Attachment within the stoma
  - Provox® Lary Button™, Provox® LaryTube™, Burton-Mayo™ (BM) button, Fahl Laryngotec Tubes

Intraluminal + Peristomal Attachments
- Provox® LaryTube™ with Blue Ring with baseplate
- Kapi-Gel™ washer with button/tube

Six different types
- Regular
- FlexiDerm™
- XtraBase™
- Stabilibase™ (reg or OptiDerm™)
- OptiDerm™
- Luna™

Three different shapes
- Oval / round and "plus" size options (except for XtraBase, Stabilibase & Luna)

Life: dependent on the patient
**Provox® STABILIBASE**

- Firm base
  - Vertical stabilizing bars
  - support during speech
  - Flexible sides
  - easy applying
- Conical design
  - Deep set stomas
- 3 piece peel-off liner
- Larger area Flexiderm type adhesive
  - Longer device life?
- Fits a variety of stoma shapes
  - Fits flat stomas
  - Fits deep stomas

**PROVOX LUNA ADHESIVE**

- Soft and smooth for nighttime comfort
- Made of hydrogel to help soothe and cool the skin
- Smaller and softer adapter for comfort regardless of sleeping position
- Provox Luna ShowerAid, Provox Adhesive Strips

**InHealth® Adhesive Base Plates**

Three different types:
- TruSeal Contour™
- PVC nondisposable valve housing™
  - Standard
  - large
- Silicone nondisposable valve housing
  - Standard
  - large
- Adhesive tape discs
  - Regular
  - Heavy duty
- Foam Discs
  - Regular
  - thin
- Life: dependent on the patient
**Hydrosoft**
- Soft, hydrocolloid material

**Hypoallergen**
- Skin-friendly

**Comfort**
- High adhesive properties

**Extra Fine**
- Waterproof base plate

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**Which Baseplate?**
- Take a guess
- Soft disposable (flat peristomal area)
- Hard disposable (recessed peristomal area)
- Non-disposable baseplate/foam disc
  - Spread area around the stoma
  - Attach the baseplate by maximizing surface contact
  - Smooth out/no air bubbles

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**Intraluminal Attachments**
**Provox® LaryTube**

- **Standard**
  - Maintains tracheostomal patency
  - Houses HME
  - Allows for customized fenestration to allow TE speech

- **Fenestrated**
  - Used in combination with voice prosthesis

- **Blue Ring**
  - Worn with adhesive base plate
  - Supports stomal seal with Provox® FreeHands™ HME
  - Used in acute post-op phase to avoid ties

**Fahl Laryngottee® Tubes/Buttons**

- **Laryngectomy Tubes**
  - Standard and Lingo (fenestrated)
  - Not for use with HMEs
  - Kombi (standard) and Kombi Lingo
  - Accommodates FreeHands™ HME
  - Lingo Kambicut
  - Filed fenestrations
  - Kambiclip and Kambilingo clip
  - Combine with adhesives

- **Stoma Buttons**
  - Standard (not for use with HMEs)
  - Kombi w/ (FIX) or w/out stoma eyelets

**Provox® LaryButton**

- Soft, silicone material
  - Easy to fold & insert
  - Comfortable for pt
  - Available in 4 diameters & 2 lengths

- **Ideal stomas**
  - Symmetric, round
  - Contiguous stomal lip
  - TEP position 7-15mm from tracheocutaneous juncture

- **Retains all Provox® HMEs and hands-free valves**

- **Maintains stomal patency**

- Can use w/ or w/o Provox® TubeHolder™ or Provox® LaryClips™
**Burton-Mayo™ Tracheostoma Button**

- Silicone material
  - More rigid than LaryButton™
  - Fold in ½ to insert
  - Retained only by retention flange
- Available in 4 diameters & 3 lengths
- Must have the perfect stoma
  - Symmetric, round
  - Contiguous stomal lip
  - TEP position 7-15mm from TCJ
- Retains HMEs and hands-free valve

**Assessing Stomal Topography**

1. Is the stoma deep set?
2. Are the SCMs prominent?
3. Are the clavicular heads prominent?
4. Stomal symmetry? Size? Shape?
5. What is the position of the TEP?
6. Peristomal Terrain?

**Stoma/TEP Challenges**
**Determining Best Set-up**

- Maintain a seal for 8 hours
- Complexity
- Comfort
- Ease of breathing/resistance
- Cost

It takes time and troubleshooting to find the best combination.
Success requires commitment from both you and your patient.

**HME Benefits**

<table>
<thead>
<tr>
<th>Short Term Benefits</th>
<th>Long Term Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Discrete</td>
<td>• Decreased sputum production</td>
</tr>
<tr>
<td>• Improved Hygiene</td>
<td>• Improved ciliary function=</td>
</tr>
<tr>
<td>• Improved Voice (including increased Maximum Phonation</td>
<td>• improved pulmonary function</td>
</tr>
<tr>
<td>Duration and more dynamic range.</td>
<td>• More forceful cough</td>
</tr>
<tr>
<td>• Easier Stoma Occlusion for TE Speech</td>
<td>• Improved Quality of Life</td>
</tr>
</tbody>
</table>

**In Summary:**

- Respiratory Changes have a big impact on QOL
- There may be respiratory changes due to smoking/lifestyle choices that are more noticeable after TL
- Respiratory changes can be addressed with the introduction of an HME
- Remind patients to drink/take in plenty of water
HMEs are the Standard of Care for ALL Neck Breathers

![Image of a dog wearing a mask]

BIBLIOGRAPHY


Mark W. Millard, MD1
Dispelling the myths of exercise and asthma: From the Baylor Asthma and Pulmonary Rehabilitation Center, Dallas, Texas. Corresponding author: Mark W. Millard, MD, Baylor Asthma and Pulmonary Rehabilitation Center, 4004 Worth Street, Dallas, Texas 75246. Presented at internal medicine grand rounds, Baylor University Medical Center, December 3, 2002.