

A BETTER WAY TO HUMIDIFY THE AIRWAY OF THE TRACHEOSTOMY PATIENT

AN ALTERNATIVE TO TRACH MIST

Phillip D. Polin, RRT

The following is a report of an evidence-based study conducted at Willows Center, a sub-acute facility in northern California. The study spans twenty-six months and approximately 3500 patient days. Ten patients were selected for this study. The patients were involved in this study for varying lengths of time, one of them for two weeks, and two of them for the entire length of the study. The remaining patients were involved for periods of time ranging from approximately six months to approximately eighteen months. All of the patients involved had tracheostomy tubes in place during the study, and were using cool tracheostomy mist as the only form of humidification prior to the beginning of the study.

The study is essentially with regards to a device that was configured to include the use of a Heat Moisture Exchanger (HME) for the purpose of replacing the misting device as the sole means of humidification during an extended, continuous and indefinite period of time for this patient population

There were five Respiratory Therapists, ten Registered Nurses and a Medical Director involved in the study. There were also a number of Certified Nursing Assistants whose function was to properly position the device when turning the patient and to provide feedback to other licensed personnel regarding the device and attention to patient care that might be required.

The writer begs a certain leniency from the reader. The study began as an experiment to determine one thing, but evolved into something entirely different. The results were both surprising and encouraging. Although the first part of the study did prove what we were hoping, the second part revealed a much more important piece of information, one that may have profound implications regarding care of the patient with tracheostomy tube placement. The results of the study, though not intended to do so, call into question one of the pillars of current respiratory clinical practice, a practice which has been used for several decades-the use of either cool or heated mist for humidifying the airway of the patient with tracheostomy.

Purpose

The purpose of the study was to determine if it were possible to safely use a Heat Moisture Exchanger (HME) in place of trach mist for continuous, uninterrupted use, and for an indefinite period of time. It is important to explain some of the environmental factors at the facility which houses this sub-acute unit.

It is an old building, and is located in a county which regularly experiences outside temperatures reaching 100+ degrees F. Room temperatures can exceed 80 degrees F. In addition to central air conditioning, portable air conditioning units were necessary in each room to moderate temperature levels. The use of air compressors to power the misting devices along with oxygen concentrators for those patients requiring supplemental oxygen delivery were factors contributing to this overheating problem. This equipment, along with the mist bottles, portable suction machines and portable medication compressors contributed to a significant and uncomfortable level of noise. The initial purpose for this study was the reduction of these factors without jeopardizing patient care in other respects.

The standard way of delivering mist to a tracheostomy at this facility is described as follows: an air compressor was used to drive the misting bottle. Attached to this was a length of corrugated tubing, which connected to a drainage bag. A second length of corrugated tubing attached to the proximal side of the drainage bag, and continued to a standard tee piece which then attached to the tracheostomy tube. Connected to the distal side of the tee piece was a six inch piece of corrugated tubing which essentially served as a mucus drainage port. A towel was placed open, underneath the end of the 6 inch tubing to allow for mucus drainage in the event a patient coughed spontaneously prior to being suctioned. The towel, if soiled, was replaced at a minimum of every two hours when the patient was repositioned. In the event that supplemental oxygen was required, it was placed in line at an appropriate position. The airway was suctioned as needed using either a single use catheter, or a closed suction system. These items were disposed of at regular intervals as recommended by each manufacturer.

Phase 1

The combination device configured for this study was comprised of an HME (the Thermoflo HMEF 6000SA with a built in bacteria barrier from ARC Medical), a closed, in line suction system (either Kimberly-Clark or Halyard) with the section of corrugated tubing attached for flexibility, a tee piece (Air-Life 001507) used as a connecting piece for the various components, a spring-valve tee piece (Pulmodyne 313-2061) for medication administration, a suction port (AirLife 001507) for removal of secretions collecting in the device, a medication nebulizer, and an oxygen port and tubing if required. These components were assembled into a single unit. {The Thermoflo HMEF 6000SA had previously been selected as the HME of choice for patients requiring mechanical ventilation at this facility with satisfactory results.}

Education was prepared and given to the various staff members based on their involvement in the study, with attention given to patient safety, patient response, positioning of the device, and to the level of secretions collecting within the distal end of the device, and secretion characteristics. Feedback was requested from each staff member so that appropriate adjustments could be made.

The patients selected for the study had the following diagnosis: traumatic brain injury, anoxic brain injury subsequent to cardiac arrest, trauma not involving brain injury, and CVA. Some patients began the study at its initiation, while others were included later as they were admitted to the facility. All had been using cool tracheostomy mist prior to their involvement the study. Most had been receiving supplemental oxygen between 2 liters and 7 liters per minute.

The device is essentially a chamber through which the patient breathes, similar in some respects to the upper airway through which a person breathes when tracheostomy is not involved. The various components of the device are configured in the following manner- the closed suction system is attached to the tee piece, with the temperature probe port pointing downward. This tee then attaches to the spring valve tee which can be rotated down when used for medication administration with the nebulizer attached, or rotated upward when not in use, with the nebulizer detached. On the distal end of the spring tee, a suction port is attached. This port is used to evacuate secretions which may have collected inside of the device in the event that the patient has coughed spontaneously. The HME sits on top of the first tee piece. Supplemental oxygen can be attached to the HME as needed. This completes the assembly.

The device, when configured in this manner, and attached to the tracheostomy tube, rests in a roughly horizontal plane, with the distal end resting naturally a few degrees lower than the proximal end. This position results from the combined influence of the flex tubing and the swivel port that are included in the closed suction system packaging, and the weight of the HME. This resting position is both convenient and essential for the removal of secretions from within the device, and contributes in other positive ways, as will be shown.

As the patient exhales through the device, water vapor is collected by the HME, which is used to humidify incoming air. The internal temperature of the device is determined by the temperature of the exhaled air. The inhaled air is filtered by the bacteria barrier of the HME. Inherent to the bacteria barrier is a slight resistance to respiration on both inhalation and exhalation. The device, to a certain degree, mimics the function of the upper airway, as far as air filtration, humidification and temperature are concerned. These factors are largely the function of the patient's physiology, with little control exerted by external influences. This is an important distinction when comparing the function of this device to that of mist, in which the temperature and water content are largely under the control of external forces, i.e. the cool mist device or the heating device employed.

When connecting the device to the patient for the first time, the patient was observed for the following changes- respiratory rate and work of breathing, changes in heart rate and fluctuations in oxygen saturation, and the appearance of anxiety or other discomfort. For the majority of these patients, a slight change in respiratory effort could be observed while the patient adjusted to the resistance of the bacteria barrier, with the effort returning to its previous state in less than a minute. No other initial changes were observed in heart rate, respiratory rate or oxygen saturation. However, one patient appeared to be uncomfortable and seemed to have difficulty with the adjustment phase. This patient was not able to communicate purposefully, but did appear nervous and uncomfortable with the attachment. However, no significant changes in vital signs were observed. The patient was returned to

the misting device. This patient will be discussed in detail shortly. For the remaining patients, within a few minutes of attachment of the device, water vapor could be seen collecting the HME.

On the first day, HME the device was used for 15 minutes for each patient. The second day the time was increased to thirty minutes, and then to one hour. No significant changes in vital signs or adverse reactions were observed. On subsequent days the length of time was increased to four hours, eight hours, and ten hours. Each patient's condition remained essentially unchanged. The length of time was then increased to 24 hours. It should be noted here that each licensed employee was allowed certain autonomy in determining if, for any reason, the patient should be returned to the misting device. This seemed to lend a certain level of comfort to the staff members participating in the study. Upon review, it appeared that that the reasons reported for returning the patient to the misting device had more to do with staff comfort than patient response. After a few days of using the HME device, all staff members became comfortable with its use. No adverse reactions were reported.

Returning to the patient who did have some difficulty adjusting to the HME device, it should be noted that the Thermoflo HMEF is available in more than one model. It can be acquired without the bacteria barrier, so that the resistance that can be felt when breathing through the barrier is eliminated. Using this model was essential for helping this patient adjust to the HME device. As soon as the resistance was removed, the patient appeared to be comfortable. This HME was employed for a few days, at which time the zero resistance model was replaced by the model containing the bacteria barrier, and the patient did not seem to notice the change. During the adjustment phase, the patient enjoyed the humidification benefits of the HME, while at the same time avoiding the resistance.

It should be noted that the placement of a tracheostomy tube results in the upper airway being bypassed, with the resultant loss of some anatomical dead space ventilation. When the combination HME device is in use, mechanical dead space replaces the anatomical dead space which was lost, and this has an influence on the system. This dead space is similar in volume to the upper airway dead space. When ETCO₂ was measured, the increase was minimal, ranging between 1mm Hg and 3mm Hg, as compared to trach mist when measured at the point of attachment nearest the tracheostomy tube.

After a period of several weeks, it was possible to speculate that the use of trach mist could reasonably be discontinued barring any negative developments. As will be shown, none of these developments were forthcoming. It was possible to safely discontinue the use of tracheostomy mist. The patients appeared to be comfortable, their secretions were of a reasonable consistency, and there were no indications of respiratory distress. As was stated in the introduction, some of these patients have been using the HME device uninterrupted for more than two years without difficulty or adverse reaction. During the summer months, the room temperatures were decreased by approximately 10 degrees F. The noise levels were decreased significantly with the elimination of the air compressors and mist bottles. An unexpected benefit was the reduction in the use of oxygen concentrators which will be discussed in part 2 of this report. Laundering costs were reduced by eliminating the need for mucus drainage towels, and of great benefit was the elimination of exposed secretions gathering on the patient or linens, as all secretions are contained within the device itself, until evacuated by the suction port. When a licensed staff member is caring for the patient, and observes secretions collecting in the distal

end of the chamber, a suction line is attached to the suction port, and the secretions are evacuated to the suction canister without being exposed to the outside environment.

After several weeks, the study was considered to be successful, with the primary benefits being that the patient rooms were very quiet for the first time in years, which by itself was enjoyable. The rooms were much more comfortable due to the lower temperatures. The patients appeared more restful. The facility enjoyed cost savings on several fronts, as less electricity was being used, with much less maintenance required for either air compressors or oxygen concentrators, and the elimination of laundering costs for the drainage towels. The costs of the disposables for either trach mist or the components that make up the HME device were similar, depending on the supplier. One aspect that was greatly appreciated by the staff was the elimination of exposed secretions which had previously gathered either on the patient or the linens, with no accidental contact with mucus secretions by care givers, because the mucus was now being contained within the device. Unsightly and unpleasant messes were no longer a problem for the patient, family members, or staff. Tracheostomy dressings remained clean and dry. Although impossible to quantify, it can reasonably be assumed that the disappearance of secretions from the environment had a positive effect on infection control.

At the present time, the device has been employed for more than 3500 patient days. Trach mist has been used 12 patient days. All patients with tracheostomy tubes in place and not requiring mechanical ventilation are using the HME device continuously without adverse effect. The patients who have used trach mist fall into three categories. When a patient is admitted to the unit, they are left on trach mist for 24 hours to observe their baseline condition before being placed on the HME device. During the adjustment phase, the patient may be temporarily placed on trach mist. If a patient develops a condition in which volume of secretions is such that the HME could become overwhelmed between staff member visits, such as in acute pneumonia, the patient may be placed on trach mist, and the secretions allowed to drain onto a towel. As can be seen by the small number of patient days during which trach mist has been required, these events have been infrequent.

Phase 2

As stated earlier, what began as an effort to reduce both temperature and noise levels evolved into something entirely different and unexpected. This is where the writer requests some degree of latitude, as the findings reported here cannot be evaluated by statistics alone.

During the weeks following the initial phase of the experiment, a number of changes in each patient's condition were observed. The first of these was that their oxygen saturations began to rise, and as a result of this, oxygen flows were reduced accordingly. After a few more weeks, all oxygen levels were titrated to room air, except for one patient whose oxygen flow was reduced from 7 liters per minute to 2 liters per minute. As a result of this, the use of oxygen concentrators was eliminated except for one,

further reducing heat and noise levels in the rooms, and reducing other costs associated with maintaining this equipment.

Another change that was observed was that of the mucus itself. We began to notice changes in color, consistency, odor and volume. These will be discussed one at a time.

Color--after the initial period of use, perhaps two weeks, we began to observe that the mucus color of several of these patients began to lighten, regardless of the color of the secretions while the patient was using mist. The greens became a lighter shade of green, and the yellows became lighter shade of yellow. As time passed, all of these became either very light yellow, white or clear. Of special interest to us was the color change in the mucus of one patient, who on occasion, would produce very large plugs that were either dark green, or brown. After using the HME device, these plugs were not reported again. This patient wore the device for entire study, or twenty six months. His secretions have remained either clear or pale yellow.

Odor--it had previously been observed that while using trach mist, the suction canisters for several these patients emitted foul odors when the suction machines were in use. After using the device for a few weeks, these odors began to dissipate, and as the sputum color improved, these odors were essentially eliminated.

Volume--as the color and odor improved, the volume of secretions also seemed to be reduced. The amount is impossible to quantify, however. Although these patients, while using mist, were being suctioned at interval, they were also coughing spontaneously, and the expelled secretions drained onto a towel. This mucus did not get collected in the suction container, but instead was laundered. After the patients began using the HME device, all secretions were collected into the suction container, whether these secretions were suctioned directly from the patient's airway via the closed suction system, or alternatively evacuated from the HME device itself, via the distal suction port. In either case, these secretions were not measured per volume. Our conclusion that secretion volume had decreased was made purely by observation, and we believe this assessment to be correct.

Consistency--This is an area of particular interest. While it was originally speculated that using the HME device on a continuous basis could result in thickened or encrusted secretions, the opposite was actually the case. With the exception of two patients, regardless of the length of time using the device, the consistency of the secretions can be accurately described as excellent, soft, easily suctioned or easily expelled by spontaneous cough. Their secretions have never been encrusted. Regarding the two patients whose sputum consistency differed did so in the following manner-one patient had slightly thicker secretions from the others, and was reported on two occasions that he had mucus plugs which required assistance with saline lavage, suctioning and hyperinflation to evacuate. This patient has been using the device for approximately one year. The second patient had a traumatic brain injury that resulted in his inability to swallow. He suffered from large volumes of frothy oral secretions which were very difficult to manage. In this respect, it was difficult to distinguish a meaningful difference when using the HME device as compared to mist. However, the oxygen flow was decreased from 7 liters per minute to 2 liters per minute.

Infection rate-- during the first year of use, the incidence of pulmonary infections requiring the use of antibiotic therapy declined by nearly 80% when compared to using trach mist. During the second year, the decline was about 50%, with the overall decline for the study being 65%. Much thought has been given to the possible reasons why this would be the case. However, it would appear that when the lower airway is given adequate protection from the outside atmosphere, the lower airway is quite capable of performing more normally.

Inherent in the design of the body of the HME device are certain characteristics which lend themselves in a positive way to respiratory physiologic function, and in these ways, the device tends to mimic the function of the upper airway, the impact of which was lost when the tracheostomy tube was placed. At first glance, the device is simply an awkward assortment of various components. However, closer inspection reveals some important characteristics that deserve discussion. The first of these is the bacteria barrier itself.

We have said that the influence of the upper airway is lost when the tracheotomy is performed, which is correct. We know that anatomical dead space is bypassed, and along with that, the filtration system, the humidification system, the heating system, the infection control system, the alveolar inflation system and voicing system are all lost. Swallow function is also compromised. The application of trach mist is an attempt to reemploy the humidification system, and in the case of heated mist, the heating system. We will see in a few moments that what is lost, and why it is lost can be better understood by closer inspection of the bacteria barrier.

The HME device is a semi-closed system. This is due to the presence of the bacteria barrier. What this means is that the internal environment (inside the patient) and the external environment, (the atmosphere) are not in direct communication with one another. They are separated by a filtration barrier and an air space. Another way of describing this would be to say that the lower airway and the external environment do not directly communicate. In this way, the device is similar to the human airway, in which the lower airway and the external environment are separated by a filtration system and an air space, i.e., the upper airway. This positioning is critical to pulmonary health, as will be seen. The purpose of the upper airway is to keep the external environment from direct contact with the lower airway, and normally, in the person who does not have a tracheostomy tube in place, the respiratory system functions perfectly, because the communication between the external environment and the lower airway is indirect. The outside eventually finds its way to the inside, but must first pass through the upper airway, which separates the two while proper preparations are being made. These preparations include, but may not be limited to humidifying, heating and filtering of the incoming air. When trach mist is applied, there is no separation between the external environment and the lower airway. This invites all of the responses that we normally see in patients who have undergone tracheotomy-increased secretion production, increased need for suctioning, increased work of breathing, increased oxygen demand, increased requirement for antibiotic therapy, increased anxiety and generalized discomfort, to name a few. We do not see these responses in a normal, healthy human until we replace the upper airway with a tracheostomy tube, and then we do.

As this study indicates, when the HME device is employed, these responses are either reduced or eliminated. This is due in part to the presence of the bacteria barrier which separates the external environment from the lower airway, and in between the two is a chamber where there exists an air space, and in this airspace there is humidity, heat, infection control, and an influence on alveolar inflation. In the normal human anatomy, between the external environment and the lower airway is an airspace which separates the two, and in this airspace is humidity, heat, infection control, and an influence on alveolar inflation. In these ways the device mimics the function of the upper airway.

To expand on this point, allow ourselves to speculate. Let us assume, for the sake of discussion, that the air that we breathe is a foreign substance, foreign in this respect-it is not perfectly suited for its intended purpose. It will work okay, but not perfectly. If used in its present form, the process of respiration will take place, but there will be certain functions that will not perform optimally. For this performance to be maximized, this air must be transformed into something slightly different. To accomplish this it must pass through a filtering container, the function of which alters the air in such a way that when it reaches its destination, the lungs, it is no longer considered to be a foreign substance. Such is the nature of the upper airway. It prepares the incoming air so that there is no disagreement between the air and the lower airway.

Further, what is in the upper airway when the inhaled air enters this container? - exhaled air. And why is this important? Because the exhaled air belongs to the person breathing it, and as such, it is acceptable to that person, and is therefore not a foreign substance. The outside atmosphere does not belong to the person who is about to breath it in. It belongs to the world, and as such, is a foreign substance. In order for this air to become familiar to the lower airway without doing battle with it, it must first pass through the upper airway so that it can mix with the exhaled air and be transformed into a substance which is familiar to the person breathing it. As a result of this mixing, no battle ensues.

What is the HME device? It is a filtering device and a container which houses the exhaled air which belongs to the person who exhaled it, and is familiar with it, and allows the incoming air to be transformed in such a way that it is familiar to the person breathing it, and as a consequence of this familiarizing process, is no longer a foreign substance, so that the pulmonary battles that we normally see in patients with tracheostomy are greatly ameliorated. Mucus production decreases, respiratory distress is reduced, oxygen requirements are reduced, coughing is reduced, the need for antibiotic therapy is reduced, mucus characteristics improve, and the patient takes on a more comfortable and relaxed appearance.

The resting position of the device, bending slightly lower than horizontally, allows for the flow of secretions away from the patient's airway, and towards the distal end of the chamber where evacuation through the suction port is convenient. However, the presence of these secretions inside the chamber itself makes their moisture and heat content available to the system, and thus to the patient's airway, helping to insure proper consistency of the mucus secretions.

The bacteria barrier allows for some resistance to air flow. This resistance is small, 1.5 cmH₂O @ 30 lpm, and may be useful in the following way. Upon exhalation, some backflow of air through the patient's

upper airway may be in play. This was demonstrated in the following manner-with the device attached, and a cuffless tracheostomy tube in use, a small tissue was placed in front of the patient's nose and mouth. This tissue could be seen gently moving back and forth with the patient's respirations, indicating the use of the upper airway. Whereas it has been thought that the presence of a tracheostomy tube indicates the loss of the upper airway, with the HME device attached, the upper airway, at least to a small degree, may be in use, and with it, the positive benefits that this implies. However, no other studies were conducted regarding this phenomenon.

Although not included in this study is the possibility that this resistance to expiratory flow may have some influence on alveolar inflation. Reducing previously required oxygen flows indicates this possibility.

A speech valve can be placed between the flex tubing and the closed suction system during cuff deflation in the usual manner, or when a cuffless tube is in use. However, exhalation through the HME is then diverted, and water vapor is eventually lost. The length of time a patient may use the speech valve depends on the amount of moisture that resides in the HME at the time of speech valve placement. For those patients who are allowed oral intake, the length of time for speech valve use can be increased if the oral fluid intake is adequate.

Cough--a patient using this device coughs both less frequently and less violently. It can be presumed that this is due to the decreased volume of the secretions, which can, in turn be attributed to the likelihood that the airways are less irritated. The probabilities of this condition include less frequent tracheal suctioning, the volume of air residing in the device being pre-humidified and pre-heated by the patient's exhaled air, the elimination of heated or cool water vapor introduced by external sources, and the lower airway protection provided by the bacteria barrier.

Another area of interest would be that of patient appearance-what the patient actually looked like to the observer. This, of course, cannot in any way be quantified. However, it does invite some speculation, as it is the responsibility of the caregiver to observe patient appearance when making an assessment of the patient's condition.

The patient population for this study included both alert and communicative subjects, as well as those with lower levels of consciousness. It was observed that these patients took on a more relaxed appearance. We can speculate as to the reasons why. Consider the factors that have influenced these patients. They were spending 24 hours a day in noisy, overheated rooms with the constant rumbling of compressors and concentrators. They were being suctioned frequently. They coughed both frequently and violently, and had mucus on their clothing. They were often short of breath, requiring supplemental oxygen. Whether or not a person is alert, it can be assumed that these conditions would make a person uncomfortable, and their appearance would indicate that.

Environmental Infection Control--The placement of a tracheostomy tube presents infection control difficulties, both for the patient, and the environment, which includes the surrounding area, other patients, family members and caregivers. Perhaps at the top of the list is how to manage mucus secretions. The proper place for secretions is in a suction canister which is disposed of according to

accepted protocol. However, with the use of traditional trach mist, these secretions are often in a place that is less than desirable. They can regularly be seen in a trach mask, in large bore tubing, on the patient, on the tracheostomy dressing, on his clothing, on the linens, and elsewhere. These secretions may be accidentally touched by another person, and is normally considered unpleasant and distasteful. These secretions can be carried from patient to patient. A patient with an unprotected airway may cough and expel contaminated droplets into the surrounding area.

The use of the HME device prevents this, because all of the secretions are delivered to the sealed suction canister, either through the tracheal suction tubing, or through the distal suction port of the device. Environmental contamination is minimized by its use.

Conclusion

The placement of a tracheostomy tube presents a number of challenges, both to the patient, the caregivers and the environment. To meet the challenges, clinicians have traditionally employed the use of trach mist, either heated or cool, which is considered by our profession to be an acceptable means of meeting these challenges. For all of the positive impacts that it possesses, trach mist still leaves certain challenges unresolved.

When trach mist is replaced by the use of a device which employs the use of an HME that has a bacteria barrier as part of its construction, the problems that tracheostomy placement presents, and which trach mist alone cannot attend to, are resolved, or greatly improved.

This study was conducted using a patient population comprised of stable patients who had tracheostomy placement, generally, on a long term bases. This device, designed to replace trach mist, has been shown to be highly effective for this patient population. It is not known whether these findings will translate to a less stable, acute care population. Perhaps further testing will answer this question. However, concerning the patient population involved in this study, these findings suggest that for an extended, continuous and indefinite length of time, the use of tracheostomy mist, either heated or cool, is largely unnecessary.