Mechanical Ventilation: Humidification (Respiratory Therapy)

ALERT

Do not use heat moisture exchangers (HMEs) for patients who have thick, copious, or bloody secretions, expired tidal volumes of less than 70% of the delivered tidal volume, a body temperature less than 32°C (89.6°F), or high spontaneous minute volumes greater than 10 L/min.[1] Do not use HMEs for infants.

OVERVIEW

When the upper airway is bypassed during invasive mechanical ventilation, humidification is necessary to prevent hypothermia, disruption of the airway epithelium, bronchospasm, atelectasis, and airway obstruction. In severe cases, thickened airway secretions may occlude the endotracheal (ET) tube. The American Association for Respiratory Care states that it is mandatory to humidify inspired gas during mechanical ventilation when an ET or tracheostomy tube is present.[1]

Two systems are available for warming and humidifying gases delivered to patients who are mechanically ventilated: (1) active humidification through a heated humidifier, and (2) passive humidification through an HME. There are three types of HMEs or artificial noses: hydrophobic, hygroscopic, and filtered. HMEs are better than heated humidifiers for short-term use (96 hours or less) and for use during transport.[1] A heated humidifier should be used for patients who exhibit contraindications to HME use.

Heated humidifiers operate actively to increase the heat and water vapor content of inspired gas. HMEs operate passively by storing heat and moisture from the patient's exhaled gas and releasing it to the inhaled gas.

The respiratory tract heats and humidifies inspired gas so the gas entering the alveoli is warmed to body temperature and fully saturated with water vapor. The upper airway provides 75% of the heat and moisture supplied to the alveoli.[1] When the upper airway is bypassed, the humidifier supplies this missing heat and moisture. Because the total required moisture input is 44 mg H_2O/L, the portion that is supplied by the humidifier is 0.75 × 44 mg H_2O/L = 33 mg H_2O/L.[1] During normal respiration, the humidity in the trachea ranges from 36 to 40 mg H_2O/L, and the optimal required moisture below the carina is 44 mg H_2O/L (100% relative humidity at 37°C [98.6°F]).[1]

For active humidification for patients who are invasively ventilated, the device should provide a humidity level between 33 and 44 mg H_2O/L and a gas temperature between 34°C and 41°C (93.2°F and 105.8°F) at the circuit Y-piece, with a relative humidity of 100%, to prevent the drying out of secretions in the artificial airway.[1] Although modern active heated humidifiers are capable of delivering gas at temperatures of 41°C (105.8°F) at the Y-piece, a maximum delivered gas temperature of 37°C (98.6°F) and 100% relative humidity (44 mg H_2O/L) at the circuit Y-piece is recommended, which is evidenced by the presence of condensate in the ET tube connector.[1]

When providing passive humidification to patients undergoing invasive mechanical ventilation, the HME should provide a minimum humidity level of 30 mg H_2O/L.[1] HMEs are not recommended for providing humidification to patients with low tidal volumes, such as when lung-protective ventilation strategies are used, because they contribute additional dead space, increasing the ventilation requirement and arterial partial pressure of carbon dioxide ($PaCO_2$). HMEs are contraindicated for patients who have frank bloody or thick, copious

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secretions, an expired tidal volume of less than 70% of the delivered tidal volume, body temperature below 32°C (89.6°F), or high spontaneous minute volumes (greater than 10 L/min).[1]

EDUCATION

- Provide individual education that is developmentally and culturally appropriate based on the patient and family's desire for knowledge, readiness to learn, and psychosocial state.
- Encourage questions and answer them as they arise.

ASSESSMENT AND PREPARATION

Assessment

1. Perform hand hygiene before patient contact.
2. Introduce yourself to the patient.
3. Verify the correct patient using two identifiers.
4. Assess the length of time the patient has been or will be on the mechanical ventilator to determine the type of humidification system needed.

Preparation

1. Ensure that appropriate equipment (humidification device, system to monitor inspired gas temperature and to alarm when the temperature is outside a preset range) is available to provide and adequately humidify the inspired gas.
2. Ensure that the heated humidifier is performing according to specifications.
3. Ensure that suction is set up at the bedside and functioning properly.

PROCEDURE

Passive Humidification

1. Perform hand hygiene and don gloves.
2. Verify the correct patient using two identifiers.
3. Explain the procedure to the patient and ensure that he or she agrees to treatment.
4. Place the HME inline at the Y-piece.
5. Observe for condensation in the ET tube connector.
6. Observe for a possible increase in flow resistance.
7. Observe for a possible increase in the patient's work of breathing (WOB).
8. Observe for increasingly tenacious or copious secretions.
9. Discard supplies, remove gloves, and perform hand hygiene.
10. Document the procedure in the patient's record.

Active Humidification

1. Perform hand hygiene and don gloves.
2. Verify the correct patient using two identifiers.
3. Explain the procedure to the patient and ensure that he or she agrees to treatment.
4. Place the heated humidifier system on the ventilator and connect the system to the inspiratory limb of the ventilator heated-wire circuits.
5. Fill the heated humidifier with sterile water to the desired level (if applicable).
6. Turn on the humidifier and select the temperature setting to deliver an inspired gas temperature of *at least* 34°C (93.2°F) but less than 41°C (105.8°F) at the circuit Y-piece.
7. Set the high alarm limit on the heated humidifier (if applicable) to no higher than 41°C (105.8°F).[1]

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8. Set the low alarm limit on the heated humidifier (if applicable) to no lower than 2°C below the desired temperature at the circuit Y-piece.[1]
9. Observe for condensation in the ET tube connector.
10. Monitor the inspired gas temperature at the patient's airway.
11. Observe for increasingly tenacious or copious secretions.
12. Discard supplies, remove gloves, and perform hand hygiene.
13. Document the procedure in the patient's record.

MONITORING AND CARE

1. Maintain proper temperature settings of the heated humidifier system.
2. Evaluate the consistency of mucous secretions regularly.
3. Maintain a relative humidity of 100%[1] by ensuring the presence of condensation in the ET tube connector.
4. Routinely inspect the humidification device.
5. Remove condensation from the patient circuit as necessary.
6. Inspect the passive humidification device for secretion contamination of the filter or insert; replace them as necessary.
7. Maintain appropriate high and low temperature alarm settings (if applicable).
8. Maintain the required water level in the heated humidifier.
9. Observe the patient for signs and symptoms of pain. If pain is suspected, report it to the authorized practitioner.

EXPECTED OUTCOMES

- Prevention of hypothermia, disruption of the airway epithelium, bronchospasm, atelectasis, and airway obstruction
- Prevention of ET tube or tracheostomy tube occlusion due to thick secretions

UNEXPECTED OUTCOMES

- Hypothermia
- Hyperthermia
- Thermal injury to the airway
- Impaction of mucous secretions and underhydration
- Alveolar gas trapping or hypoventilation
- Increased resistive WOB
- Hypoventilation
- Increased resistive WOB through the heated humidifier
- Electric shock hazard with heated humidifier
- Accidental tracheal lavage
- Increased airway pressure
- Patient–ventilator asynchrony
- Low-pressure ventilator alarm malfunction in the event of patient disconnection

DOCUMENTATION

- Patient and family education
- Type of humidification system used
- Quantity and consistency of mucous secretions
- Humidifier setting
- Inspired gas temperature near the patient's airway
- Heated humidifier alarm settings (if applicable)

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- Water level and function of automatic feed system (if applicable)
- Unexpected outcomes and interventions

HOME CARE CONSIDERATIONS

- The respiratory therapist (RT) should instruct the patient and caregiver about the humidification system, temperature settings, and alarms.
- The RT should ensure that the patient or caregiver knows how to detect and report changes in the consistency and quantity of mucus.

REFERENCES

1. Restrepo, R.D., Walsh, B.K. (2012). AARC Clinical practice guideline: Humidification during invasive and noninvasive mechanical ventilation: 2012. *Respiratory Care, 57*(5), 782-788. doi:10.4187/respcare.01766 (classic reference)* (Level VII)

ADDITIONAL READINGS

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Lellouche, F. and others. (2014). Influence of ambient temperature and minute ventilation on passive and active heat and moisture exchangers. *Respiratory Care, 59*(5), 637-643. doi:10.4187/respcare.02523

*In these skills, a "classic" reference is a widely cited, standard work of established excellence that significantly affects practice and may also represent the foundational research for practice.

Elsevier Skills Levels of Evidence

- Level I - Systematic review of all relevant randomized controlled trials
- Level II - At least one well-designed randomized controlled trial
- Level III - Well-designed controlled trials without randomization
- Level IV - Well-designed case-controlled or cohort studies
- Level V - Descriptive or qualitative studies
- Level VI - Single descriptive or qualitative study
- Level VII - Authority opinion or expert committee reports

Supplies

- Gloves
- Humidification device (HME or heated humidifier)
- Sterile water
- System to monitor inspired gas temperature of the heated humidifier and to alarm when the temperature falls outside a preset range
- Ventilator heated circuit
- Ventilator circuit for HME

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