Review / Update

HUMIDIFICATION OF RESPIRATORY GASES – SELECTION OF BEST METHOD FOR IN-HOSPITAL AND TRANSPORT VENTILATION.

OVERVIEW

Heat and moisture exchange is one of the most important functions of the respiratory system. The nose is responsible for warming inspired air, increasing its humidity carrying capacity. After endotracheal intubation however, the upper airway is circumvented and the respiratory system loses its capacity to heat and moisten inhaled gas. This imposes a burden on the lower respiratory tract, which is not designed for the humidification process. Consequently, delivery of partially cold and dry medical gases brings about potential damage to the respiratory epithelium, manifested by increased work of breathing, atelectasis, thick and dehydrated secretions, and cough and/or bronchospasm,

Used to provide warmth and humidification of respiratory gases patient circuit humidifiers come in two types:

A **"WET CIRCUIT"** is a breathing circuit with **active** humidification (Fig. 1).

A **"DRY CIRCUIT"** uses a Heat and Moisture Exchanger (HME) (or a Heat Moisture Exchanger Filter - HMEF) and provides **passive** humidification (Fig. 2).

DESCRIPTION OF THE TWO SYSTEMS

The **"WET"** circuit requires power for heating the water, a disposable or reusable humidification chamber that holds water +/- a reservoir that adds water as needed, a heating element to warm water and ideally, a heated (e.g. by a heated wire along the tube) and insulated inspiratory tube that transmits heated, humidified gas. If this tube is not heated, condensation ("Rain Out") will occur and a water trap will be required. A temperature monitor (at the patient end of the circuit) adjusts the amount of heating required to maintain the correct humidity.

The **"DRY"** circuit is a simple breathing circuit component requiring no heat or water to operate. The HME contains a layer of foam or paper embedded with a hydroscopic salt such as calcium chloride. Expired gas cools as it crosses the membrane, resulting in condensation and heat transference onto the HME layer. On inspiration absorbed heat evaporates the condensate and warms the gas, the hygroscopic salt releases water molecules when the vapor pressure is low, warming and humidification is thus regulated by the moisture content of the expired gas and patient's core temperature.

METHOD OF INSERTION AND/OR USE

The **"WET"** circuit is inserted into the inspiratory limb of the ventilator circuit and requires specialized auxiliary equipment and heated circuit tubing.

The **"DRY"** HME or HMEF is inserted between the circuit and the endotracheal tube.

EFFICIENCY

Both **"WET"** and **"DRY"** humidifiers provide a minimum of 30mgH_2O/L delivered at an appropriate temperature.

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Advantages and Disadvantages of the two types

"WET" Humidification

Disadvantages

- Should not be used with a HME
- Must not be placed in the expiratory limb
- If a filter is used with active humidification it should be upstream to prevent clogging with water
- You must ensure the heated humidifier is turned off if there is no flow through the circuit. If not, the absence of flow will cause temperature to fall at the patient end, leading to increased heat output which may cause the inspiratory tube to melt.
- Condensation ("rain-out"): risks water aspiration
- Potential delivery of excessively hot fluid to the airways.
- May interfere with monitoring (e.g. flows and volumes)
- May damage equipment (e.g. ventilator)
- Microbiological colonisation and growth (e.g. in reservoir or condensate)
- Over hydration
- Thermal injury
- Increased work of breathing due increased resistance (some cannot be used with spontaneously breathing patients)
- Potential electrical hazard
- Lack of transportability
- Increased cost and maintenance
- Not all humidifiers are compatible with all circuits
- Increased work for staff (temperature control, refilling the reservoir, draining condensate, cleaning, and sterilization)

Advantages

- Optimal efficiency (generally more efficient than a HME)
- Reliability
- Ability to warm patient
- Proven track record of safety
- Some can be used for spontaneously breathing and tracheotomised patients

"DRY" Humidification

Disadvantages

- Inability to use with all patients (hemoptysis, tenacious secretions)
- Increased airways resistance
- Increased dead space
- Potential for unrecognized airway obstruction if filter blocks
- Less than full humidification and body temperature
- Drying of secretions
- Not appropriate for patients with large air leaks (e.g. bronchopleural fistulae) due extensive loss of inspired gas and inability to conserve heat and humidity

Advantages

- Ease of use
- Lightweight
- Can retain their ability to humidify for up to 4 days with minimal change in resistance
- Less cumbersome during transport
- Lower staff workload
- Lower costs
- Decreases ventilatory acquired pneumonia

CONCLUSIONS

Airway humidification is a key adjunct in the mechanical ventilation of patients. Humidifier devices may function passively or actively, depending on the source of heat and humidity.

Incorrect humidification or the selection of the wrong device for the ventilator application (in-hospital, transport etc.) may have a negative impact on patient outcomes or may create hazards for the healthcare professional.

The selection of the right type of humidification device for the right application is therefore essential and knowledge of the advantages and disadvantages of each of the two types of device is essential to making that right choice.

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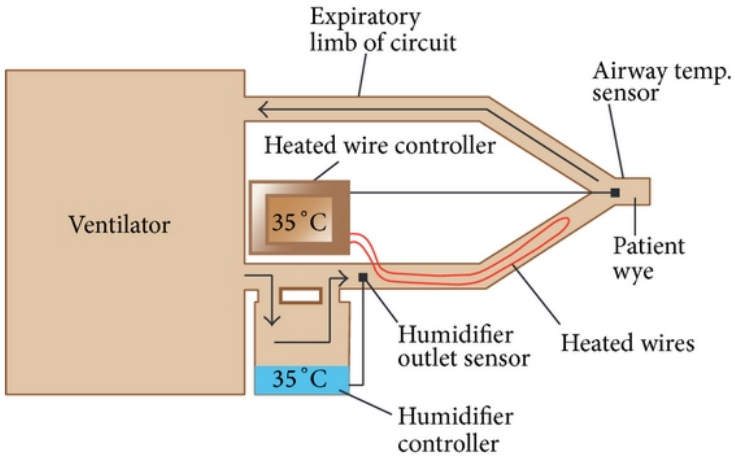

Fig. 1 "WET" Humidifier system with Heated wire in the inspiratory limb
(Adapted from Egan's Fundamentals of Respiratory Care, 10th edition, St. Louis: Mosby-Elsevier; 2012:1424 [17].)

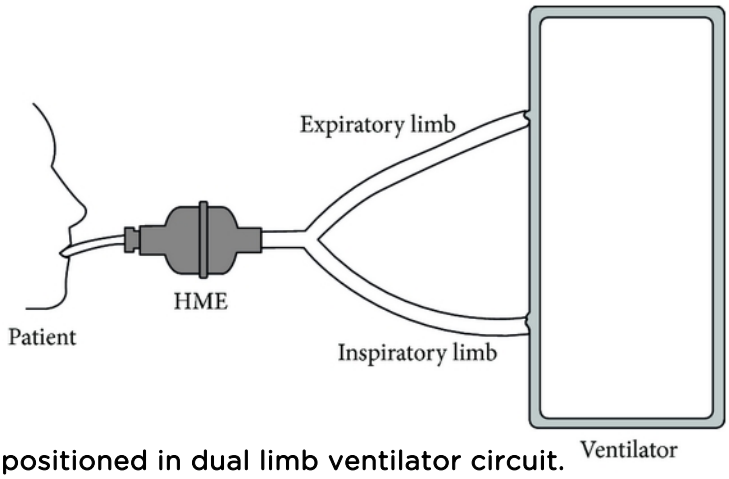

Fig. 2 "DRY" HME positioned in dual limb ventilator circuit.

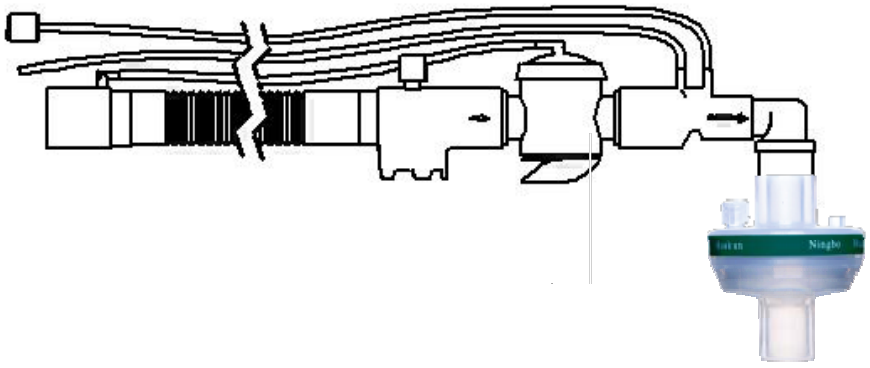

Fig. 3 Position of "DRY" HMEF on O-Two eSeries patient circuit

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