Humidification for patients with respiratory failure

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Objectives

• Physiologic principles of water vapor.
• Adequate humidification for MV patients.
• Advantages and disadvantages of heated humidifier (active humidification)/heat and moisture exchanger (passive humidification).
• The way how to use humidifying devices effectively and safely.
Water vapor

• Humidity is water present in a gas mixture as a vapor.
• Increasing the temperature increases the ability of the gas to hold water vapor and vice versa.
• Absolute humidity (mg/L)
  – actual mass of water present in 1L of gas
• Relative humidity (%)
  – actual amount of water present in a gas divided by the capacity of the gas hold water at a given temperature
Increasing the temperature increases the ability of the gas to hold water vapor.

6mg/L consolidation

RH 100%

RH 85%

51mg/L
Nasopharynx is an excellent radiator

Temperature 32°C  
RH 95%   AH 33 mg/L

Temperature 37°C  
RH 100%   AH 44 mg/L
ETT bypasses natural radiator and dry & cold gas can reach the lungs
Inadequate humidification injures ciliated epithelial cells

healthy

damaged
Dry & cold air impairs ciliary function immediately
Dry & cold air impairs ciliary function immediately
ETT was completely occluded by thick mucus due to inadequate humidification
Dry gas inhalation damages the lungs resulting in respiratory failure
Adverse Effects of Inadequate Humidification

- Heat loss
  - hypothermia
- Moisture loss
  - epithelial damage
  - mucus plugging
  - ulceration of mucosa

- Alveolar injury
What is adequate humidification?

• Adequate humidity?

11.1.2 Humidification systems intended for use in patients whose supraglottic airways have been bypassed shall also be capable of producing a humidifier output of at least 33 mg H₂O/L.

8185:1997, Section 11: Additional requirements specific to humidifiers
Two Types of Humidifying Devices

- Heated humidifier (active humidification)
- Heat and moisture exchanger (passive humidification)
HH with a heated wire

Warming ventilator circuit reduces condensates.

By heating a water reservoir, both heat & vapor are added to the dry and cold medical gases.
Gas temperature decreased along the inspiratory limb quickly.
Absolute Humidity; 37°C

Nishida T. J Aerosol Med 2001
HME: heat & moisture exchanger

- Advantages
  - Easy to use
  - No electronic devices
  - No water
  - No condensation
  - Pneumonia ↓

- Disadvantages
  - Humidifying?
  - Heating?
  - Dead space
  - Resistance
  - How long?
Incidence of pneumonia decreased

Martin et al., 1990
Roustan et al., 1992
Dreyfuss et al., 1995
Kirton et al., 1997
Memish et al., 2001
Overall (95% CI)
Many brands of HMEs
Humidification performance

Lellouche F. Chest 2009
Thermography of HMEs
As HME dead space increases, AH values increases
Vapor delivered from HME is influenced by the amount of leakage
Humidifying ability of HMEs

- Tidal volume, and minute volume volume

Ünal N ICM 1998; 24, 138
HME

- HMEs are unique alternative to humidify inspired gas, and have many advantages.
- Performance of HMEs differs significantly among brands.
- As $V_T$ & MV increase, AH decreases.
- HMEs are not recommended for small patients and adults with bronchial fistula.
Position of HME
Humidification during NPPV
Oral dryness during NPPV
thick mucus on the roof of the mouth
High-flow nasal cannula

AIRVO™2
(Fisher & Paykel, NZ)

Optiflow system™
(Fisher & Paykel, NZ)
High-flow nasal cannula

Chikata Y. Respir Care 2014
HME for tracheostomized patients
Humidifying devices for tracheostomized patients

AIRVO2™

Tracheomask
Absolute humidity with each device

Chikata Y. Respir Care 2013;58:1442
AH was below 30 mg/L with 3 L/min of supplemental oxygen.
Summary

• Adequate humidification is essential for critically ill patients

• Inadequate humidification can lead to fatal lung damage

• Be careful if humidification is fine