Physiology of Humidification

- Heat and moisture exchange is a function of the ________________ respiratory tract.

- During inspiration turbulent flow through the nose ensures adequate contact between inspired gas and the mucosa – as the gas is warmed, it picks up ________________ from the moist mucosal lining.

Physiology of Humidification

- During exhalation, expired gas transfers heat back to the cooler tracheal and nasal mucosa.
- As this saturated gas cools it can hold less water vapor and condensation occurs on the mucosal surfaces where the liquid water is reabsorbed.
- As inspired gas moves into the lungs, it eventually achieves ________________ conditions.
BTPS is an acronym for
Body Temperature and Pressure Saturated
This means that the gas is at body temperature and is 100% saturated with water vapor.

Physiology of Humidification
• This point is normally about _____ cm below the carina and is known as the isothermic saturation boundary (ISB)
• Above the ISB, temperature and humidity decrease during inspiration and increase during expiration
• Below the ISB, temperature and humidity remain ______________ (BTPS)

Physiology of Humidification
• A number of factors can shift the ISB deeper into the lungs
• A distal shift occurs when breathing cold, dry air, when the upper airway is bypassed (use of an artificial airway) or when the minute ventilation is higher than normal
• When a distal shift of the ISB compromises the body’s normal heat and moisture exchange, humidity therapy is indicated
Indications for Humidification

• Primary goal of humidification is to maintain _______ physiological conditions in the lower airways
• Humidity therapy can also be used to treat abnormal conditions

Indications for Humidification

<table>
<thead>
<tr>
<th>Primary Indications</th>
<th>Secondary Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Humidify dry medical gases</td>
<td>1. Manage hypothermia</td>
</tr>
<tr>
<td>2. Overcome the humidity deficit created when the upper</td>
<td>2. Treat bronchospasm caused by cold air</td>
</tr>
<tr>
<td>airway is bypassed</td>
<td>3. Treat upper airway inflammation</td>
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</tbody>
</table>

Indications for Humidification

• Administration of dry medical gases at more than _____ L/min causes immediate heat and water loss, resulting in
  – reduced
  – irritable airways
  – increased mucus production
  – thick _______________ secretions
Cilia are thread-like projections from the surface of epithelial cells lining the _______________ and _______________. They propel or sweep materials such as mucus, dust or bacteria across the surface of the respiratory tract.

If impaired, cilia are not as effective at moving mucus, which can lead to inspissation of secretions.

Inspissated is defined as thickened or hardened through the absorption or evaporation of the liquid portion, as can occur with respiratory secretions when inspired gas humidification is insufficient or when the upper airway is bypassed.

Inspissated secretions are _______________ to remove from the airways through the normal clearance mechanisms and are therefore _______________ in the airways. This can lead to partial or complete airway obstruction and infection.

Proper humidification of inspired gas may help to correct this situation.

Indications for Humidification

• The hazard of breathing dry gas is even greater when the normal humidification mechanisms are bypassed as with _______________

• As little as 2 hours of breathing dry gas can cause damage to respiratory epithelium
Indications for Humidification

- Prolonged breathing of improperly humidified gases can result in hypothermia, inspissation of respiratory secretions, destruction of airway epithelium and ________________
- Increasing inspired humidity to at least ___% of body humidity can prevent this

Atelectasis is defined as an abnormal ____________ of the lung parenchyma.

Insufficient humidification can lead to retained secretions, which in turn can lead to partially or completely obstructed airways. Without air flow and pressure, the lungs, or parts of them, collapse.

Indications for Humidification

The amount of heat and humidity needed depends on the site of delivery.

<table>
<thead>
<tr>
<th>Delivery Site</th>
<th>Temp. range (°C)</th>
<th>Relative Humidity (%)</th>
<th>Absolute Humidity (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nose/mouth</td>
<td>20-22</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Hypopharynx</td>
<td>29-32</td>
<td>95</td>
<td>28-34</td>
</tr>
<tr>
<td>Trachea</td>
<td>32-35</td>
<td>100</td>
<td>36-40</td>
</tr>
</tbody>
</table>
Indications for Humidification

- Warmed, humidified gas is also used to prevent or treat a variety of abnormal conditions
  - treat hypothermia
  - prevent intra-operative hypothermia
  - treat exercise-induced (or cold air-induced) bronchospasm

Indications for Humidification

- Cool, humidified gas is used to treat upper airway inflammation due to croup, epiglottitis and post-extubation edema