



THE PERFECT BALANCE

Protecting the Ventilated Patient from Hospital-Acquired Infections

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Objectives

- Upon completion of this module, participants should be able to:
 - Discuss the impact of HAI on health care costs and outcomes
 - Describe criteria to diagnose VAP and define VAC & IVAC
 - Discuss strategies to minimize HAI in MV patients and their associated evidence, such as humidification, circuit maintenance, cuff pressure, ETT modifications, hand hygiene, infection control, elevated HOB, oral hygiene, NIV, Daily SBTs, and use of bundles.

Introduction

- **Hospital-acquired infection (HAI)**
 - infection acquired in an acute care setting while receiving treatment for medical or surgical conditions.^{1,2}
- Among the top 10 leading causes of death in the US.¹
- 2002: ~1.7 million infected; ~100,000 died from HAIs.

1. Klevens RM, et al. *Public Health Rep.* 2007;122(2):160-166.

2. Morbidity and Mortality Weekly Report (MMWR). March 4, 2011/60(08);243-248.

Introduction

- Approx. 5% of hospital inpatients develop an HAI.¹
- More Americans die per year from an HAI than from AIDS, breast cancer, and car accidents combined.
- One half to two-thirds of such infections are preventable.²



1. Morbidity and Mortality Weekly Report (MMWR). March 4, 2011/60(08);243-248

2. McCaughey B. *Unnecessary deaths: The human and financial costs of hospital infections*. 3rd edition. New York, NY (2008)

Risk factors and frequencies for HAIs

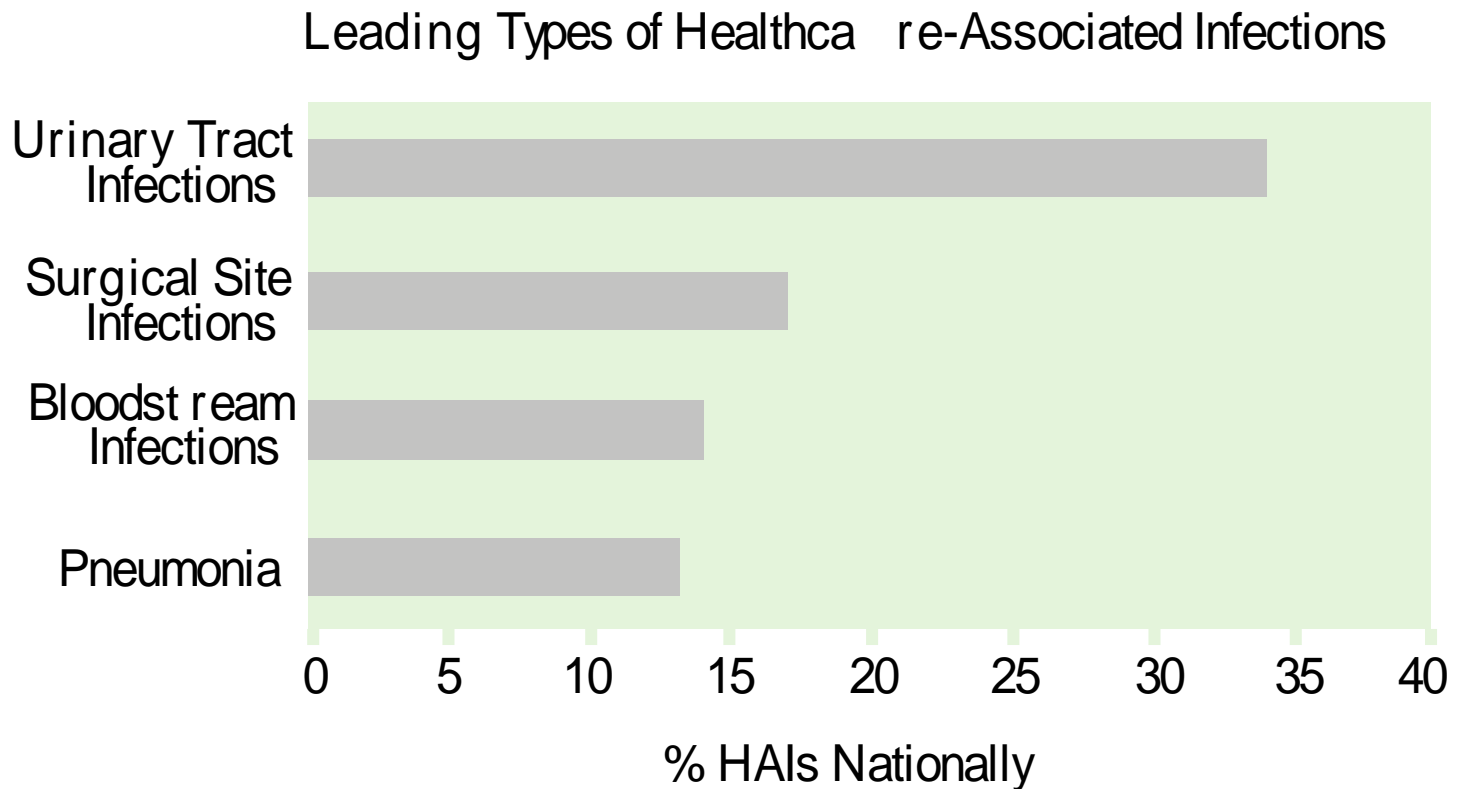
- All hospitalized patients are susceptible to contracting an HAI.
 - At greater risk: young children, the elderly, the immunocompromised, and intensive-care patients.
- Factors that increase risk of HAI:
 - long hospital stay
 - indwelling catheters, central lines, and ventilators
 - complications following surgery
 - failure of healthcare workers to wash hands
 - overuse of antibiotics

Types of HAIs

- Four categories of HAIs account for approximately 75% of infections in acute care settings:
 1. Surgical site infections
 2. Central-line–associated bloodstream infections
 3. Ventilator-associated infections
 4. Catheter-associated urinary tract infections

Rate of Occurrence of HAIs

Figure 1. Rate of Occurrence for Healthcare Associated Infections



Klevens, RM, Edwards J, Richards C, et al. Estimating Health Care Associated Infections and Deaths in U.S. Hospitals. Public Health Rep. 2007;122(2):160-166.

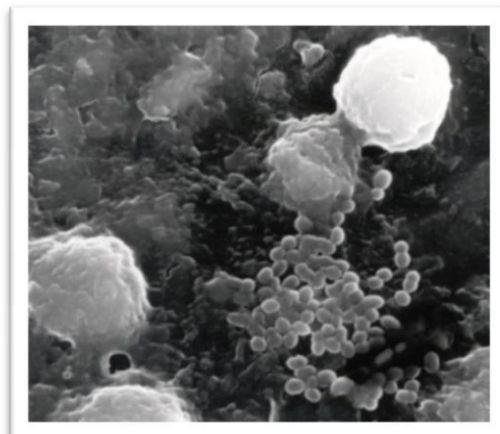
Surgical Infections

- Second most prevalent cause of HAIs.
- A surgical infection may be acquired from:
 - contaminated surgical equipment,
 - inadequate surgical site preparation,
 - healthcare workers.
- Surgical wound may become infected.
- Wounds caused by trauma, burns, and ulcers may also become infected.

Bloodstream Infections

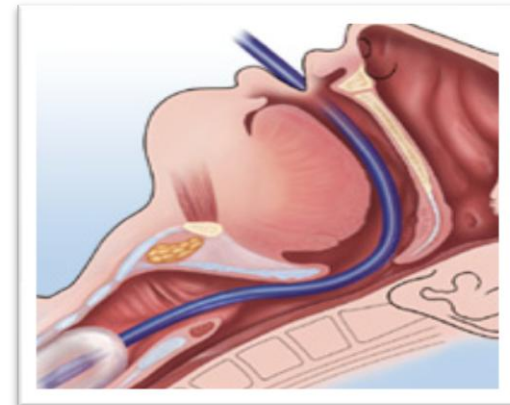
- Hospitalized patients often require an intravenous (IV) line or central access device.
- Bacteria can invade the catheter insertion site, and enter the blood through the vein.
- Bloodstream infections can be life-threatening.
- The longer a catheter is in place, the greater the risk of infection.

Girard R, et al. *Prevention of hospital acquired infections: A Practical Guide*. 2nd edition. WHO/CDS/CSR/EPH/2002.12.



Pneumonia

- Pneumonia causes approx. 13% of HAIs.
- Foreign microorganisms (MOs) can enter throat via respiratory procedures (mechanical intubation and suctioning).
- MOs can quickly colonize the respiratory tract, resulting in pneumonia.
- Hospital-acquired pneumonia (HAP) is the leading cause of HAIs among mechanically-ventilated patients in ICUs.
 - Mortality rates up to 50%.



Aspects of artificial airways that influence the development of VAP

- An artificial airway provides a direct route for bacterial colonization of the lower airway.
- The ETT acts as a reservoir for pathogens to colonize and create a biofilm within the tube.
 - Dislodging the biofilm by suctioning, coughing or tube movement can subsequently contaminate the lower respiratory tract.
 - Its cuff creates a place for secretions to “pool” and stagnate, where they can be aspirated.
- Creates a foreign body reaction in the body, interfering with local immune response.

Diaz E, et al. *Respir Care*. 2005;50(7):900-909.

Hixson S, et al. *AACN Clin Issues*. 1998;9(1):76-90.

Causes of VAP

- Colonization of oropharynx and respiratory tract with gram-negative bacilli occurs in up to 80% of intubated patients within days of ICU admission.¹
- May also occur from:
 - inhalation of infected aerosols
 - direct inoculation into the airways
 - spread of infection from another site, or
 - migration of bacteria from the gastrointestinal (GI) tract.
- **Most VAPs are thought to originate from aspirating bacteria from oropharyngeal secretions and the GI tract.²**

1. Brun-Buisson C. *Minerva Anesthesiol.* 2002;68(4):258-260.

2. Diaz E, et al. *Respir Care.* 2005;50(7):900-909.

Early-onset VAP

- Early-onset VAP occurs within the first 4 days of ventilation.
 - Commonly caused by community-acquired organisms such as *Streptococcus pneumoniae*, *Staphylococcus aureus*, and *Haemophilus influenzae*.
 - These organisms are antibiotic-sensitive.
 - Enterobacteriaceae may also be encountered.

Late-onset VAP

- Late-onset VAP develops more than 4 days after the start of mechanical ventilation.
 - Commonly caused by antibiotic-resistant gram-negative hospital-acquired organisms such as *Pseudomonas aeruginosa*, *Acinetobacter* species, *Enterobacter* species, and methicillin-resistant *Staphylococcus aureus*.
 - When VAP is caused by these virulent organisms, mortality can reach as high as 50% .

CDC criteria for diagnosing VAP

- CDC has standardized criteria for diagnosing VAP using clinical, microbiological and radiological data:
 - Chest X-ray showing new or progressing infiltrate, consolidation, or pleural effusion that persists for more than 48 hours
 - New onset of purulent sputum or change in the character of sputum
 - Fever above 38.5°C
 - White blood cell count greater than 10,000/cm³
 - Positive blood and/or sputum cultures.

Changes in VAP surveillance

- CDC's National Healthcare Safety Network(NHSN) proposed improvements to VAP surveillance.
 - The CDC's Division of Healthcare Quality Promotion (DHQP) is collaborating with the CDC Prevention Epicenters, the Critical Care Societies Collaborative, other professional societies, and federal partners.
- NHSN Surveillance for Ventilator-Associated Events in Adults
 - Ventilator-Associated Condition (VAC)
 - Infection-related Ventilator-Associated Complication (IVAC)

NHSN Surveillance for Ventilator-Associated Events in Adults

- Surveillance Definitions for Ventilator-Associated Events:
 - For use in acute and long-term acute care hospitals and inpatient rehabilitation facilities.
 - For use in patients ≥ 18 years of age who are on mechanical ventilation for ≥ 3 calendar days.
 - NOTE: patients on rescue mechanical ventilation (e.g., HFV, ECMO, mechanical ventilation in prone position) are EXCLUDED.

NHSN Surveillance for Ventilator-Associated Events in Adults

- Ventilator-Associated Condition (VAC)
 - Baseline period of stability or improvement on the ventilator, defined by ≥ 2 calendar days of stable or decreasing FiO_2 or PEEP.
 - After this period of stability or improvement, the patient has at least one of the following:
 - Minimum daily FiO_2 values increase ≥ 0.20 over baseline and remain at or above that increased level for ≥ 2 calendar days.
 - Minimum daily PEEP values increase ≥ 3 cmH_2O over baseline and remain at or above that increased level for ≥ 2 calendar days.

NHSN Surveillance for Ventilator-Associated Events in Adults

- Infection-related Ventilator-Associated Complication (IVAC)
 - On or after calendar day 3 of MV and within 2 calendar days before or after the onset of worsening oxygenation, the patient meets both of the following criteria:
 - Temperature $> 38^{\circ}\text{C}$ or $< 36^{\circ}\text{C}$, OR white blood cell count $\geq 12,000$ cells/mm³ or $\leq 4,000$ cells/mm³
AND
 - A new antimicrobial agent(s) is started, and is continued for ≥ 4 calendar days

Impact of HAIs on clinical outcomes and cost of care

- While being treated at healthcare facilities, patients acquire an estimated 1.7 million infections, leading to 98,987 deaths (2002 statistics).¹
- These numbers have attracted attention and censure, leading 20 states to legislate mandated public reporting of infection rates.
- HAIs incur nearly \$20 billion in excess healthcare costs each year.²
- Healthcare charges for *Staphylococcus aureus* bloodstream infections alone exceeded \$2.5 billion for Medicare patients in 2005.³

1. Klevens MR, Edwards JR. Estimating Healthcare associated infections and deaths in US hospitals, 2002. *CDC Public Health Reports*. 2007;122:160-166.

2. Stone PW, et al. *Am J Infec Control*. 2005;33(9):501-509.

3. Stone P, et al. *Am J Infect Control*. 2002;30(3):145- 152.

Estimated Annual Hospital Cost of Healthcare-Associated Infections by Site of Infection

Site of Infection	Total Infections	Hospital Cost Per Infection	Total Annual Hospital Cost (in Millions)	Deaths per Year
Surgical site infection	290,485	\$25,546	\$7,421	13,088
Central line-associated bloodstream infection	248,678	\$36,441	\$9,062	30,665
Ventilator-associated pneumonia (lung infection)	250,205	\$9,969	\$2,494	35,967
Catheter-associated urinary tract infection	561,667	\$1,006	\$565	8,205
TOTALS	1,351,035		\$19,542.00	87,925

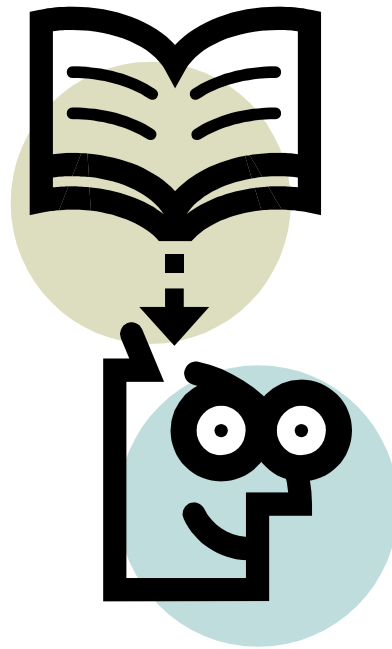
Costs of care associated with HAIs

- In 2008, the Centers for Medicare and Medicaid Services (CMS) stopped paying for three types of HAIs: surgical site infections, catheter-based UTIs and bloodstream infections.
 - CMS is considering VAP for inclusion.
- **Dwindling payments and virtually non-existent profit margins for acute care facilities, mean that controlling HAI costs will be vital to survival.¹**
- Growing demands on the healthcare system, concerns over antimicrobial-resistant pathogens and rising healthcare costs reinforce the need to address HAI's.²

1. Stone P, et al. *Am J Infect Control*. 2002;30(3):145- 152.

2. Umscheid CA, et al. *Infect Control Hosp Epidemiol*. 2011;32(2):101-114.

Strategies to minimize HAI risk



Role of the RT in Preventing HAI in Ventilated Patients

- Humidification and Filtration
- Avoiding manipulation of the ETT
- Ventilator circuit changes
- Maintenance of ETT Cuff Pressures
- Endotracheal Tube Modifications
- Hand Hygiene and Glove / Gown Adherence
- Head of Bed elevated 30 degrees or greater
- Oral Hygiene
- Use of Non-invasive Ventilation
- Assessment for Daily SBTs
- Infection Control- Disinfecting equipment
- Use of Ventilator Bundles

Reducing the Incidence of VAP

- Strategies aimed at preventing VAP should be evidence-based and multi-factorial.
- Practices must reduce the risk for aspiration of colonized upper airway secretions.
- Approaches should minimize transmission of pathogens from direct caregivers and medical devices.
- Independent predictors of VAP include:
 - need for reintubation, duration of ventilator support
 - reintubation rate, severity of underlying disease process(es), advanced age
 - altered consciousness. ^{1,2}

1. Gadani H, et al. *Indian J Anaesth.* 2010;54(6):535-40.

2. Warren DK, et al. *Crit Care Med.* 2003;31(5):1312-1317.

Reducing the Incidence of VAP

- Air- and liquid-borne contamination are modifiable risk factors.
- Although use of HMEs and HMEFs reduces microbial colonization, VAP incidence is not affected by the duration of passive humidification or the type of HME device.¹⁻³
- **CDC guidelines for the prevention of HAP:** insufficient evidence exists to determine whether HMEs are superior to active heated humidification for preventing VAP.⁴

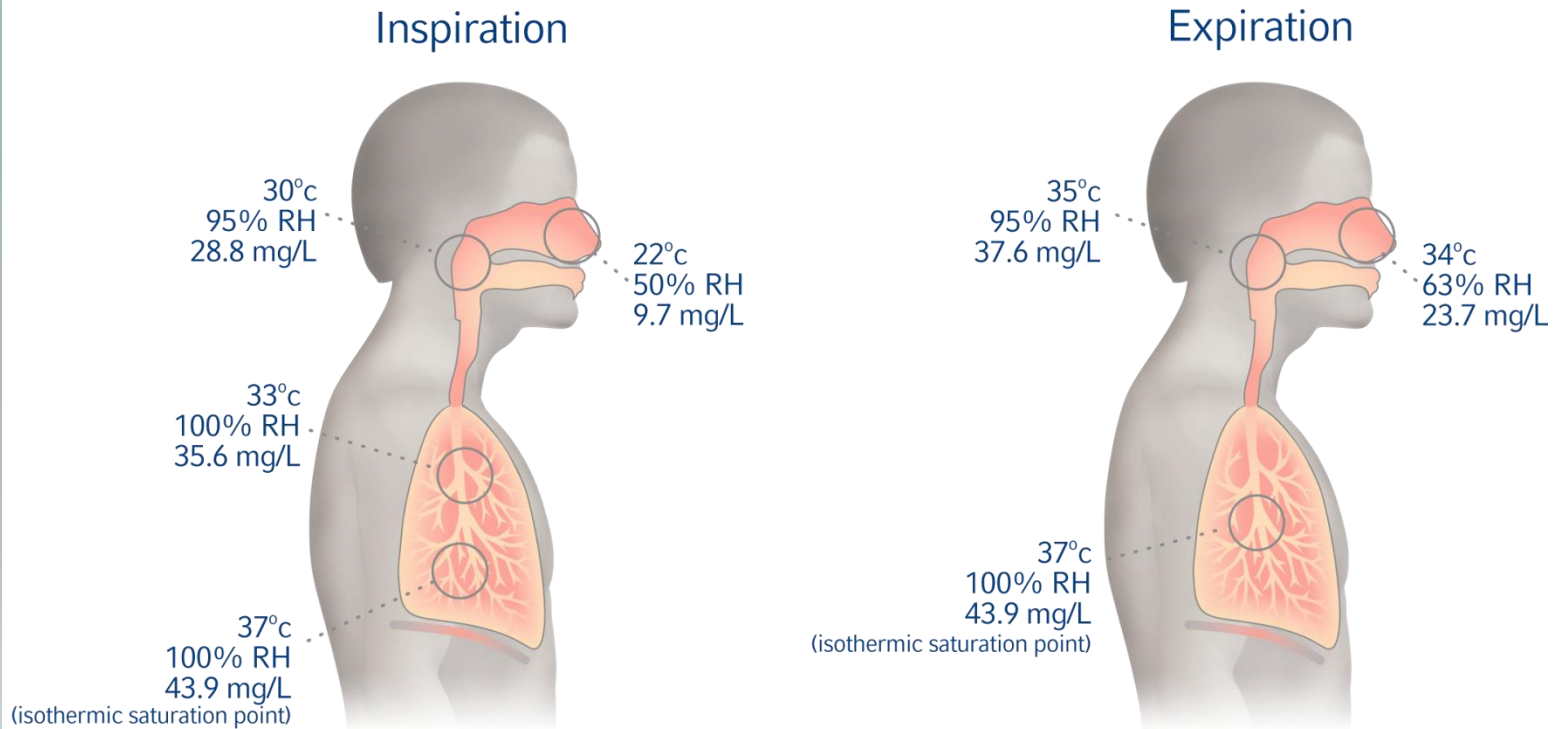
1. Lorente L, et al. *Infect Control Hosp Epidemiol*. 2004;25(12):1077-1082.

2. Ricard JD, et al. *Respir Care Clin North Am*. 2006;12(2):263-273.

3. Dries DJ, et al. *J Trauma*. 2004;56(5):943-952.

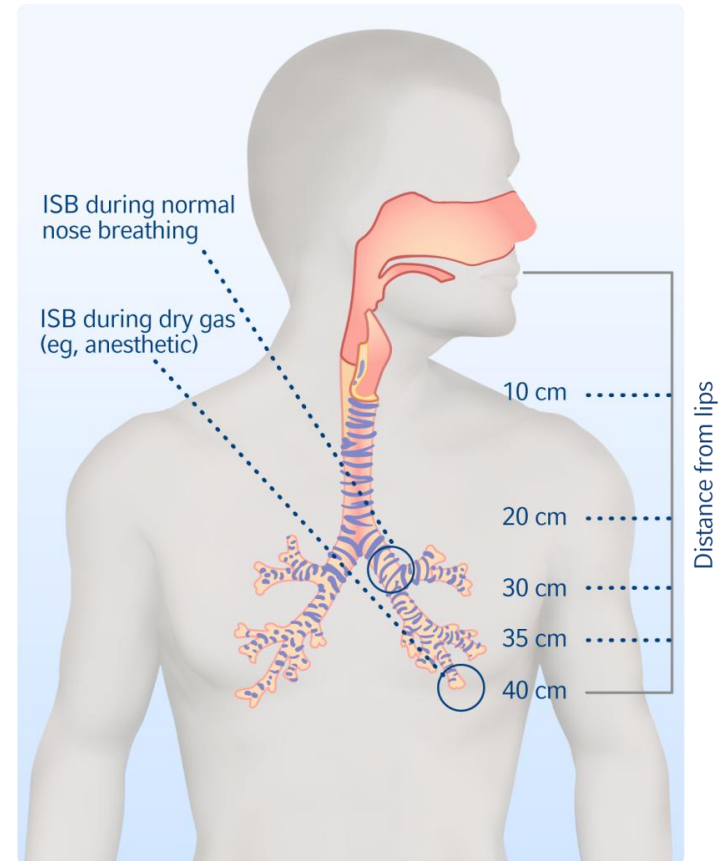
4. Tablan OC, et al. *MMR Recomm Rep*. 2004;53(RR-3):1-36.

Properly Conditioned Medical Gases



Properly conditioned medical gases

- Humidity deficit of inspired gas
 - AH is $<$ BTPS
 - Lower airway must compensate
- Effect of intubation
 - ISB is shifted down the respiratory tract
 - Humidity comes from the lower respiratory tract
 - Increased heat and moisture loss from the airways



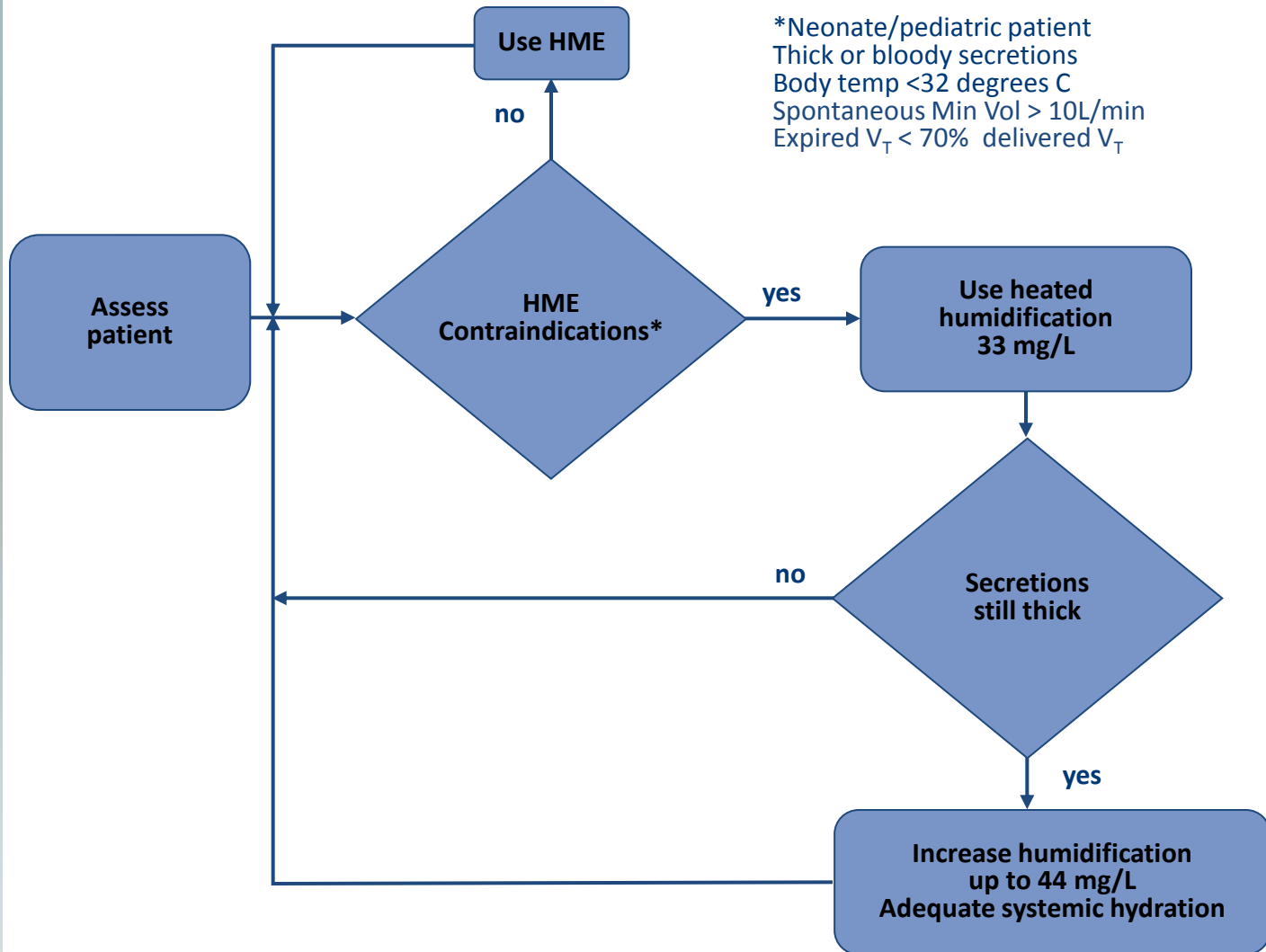
Inadequate Humidification

- Inadequate humidification = humidity deficit
 - High minute ventilation
 - Breathing cold, dry air
 - Breathing through the mouth
 - Intubation
- Physiologic effects of humidity deficit
 - Destruction of cilia
 - Cellular desquamation
 - Inflammation
 - Increased mucus viscosity

Active vs. Passive Humidifiers

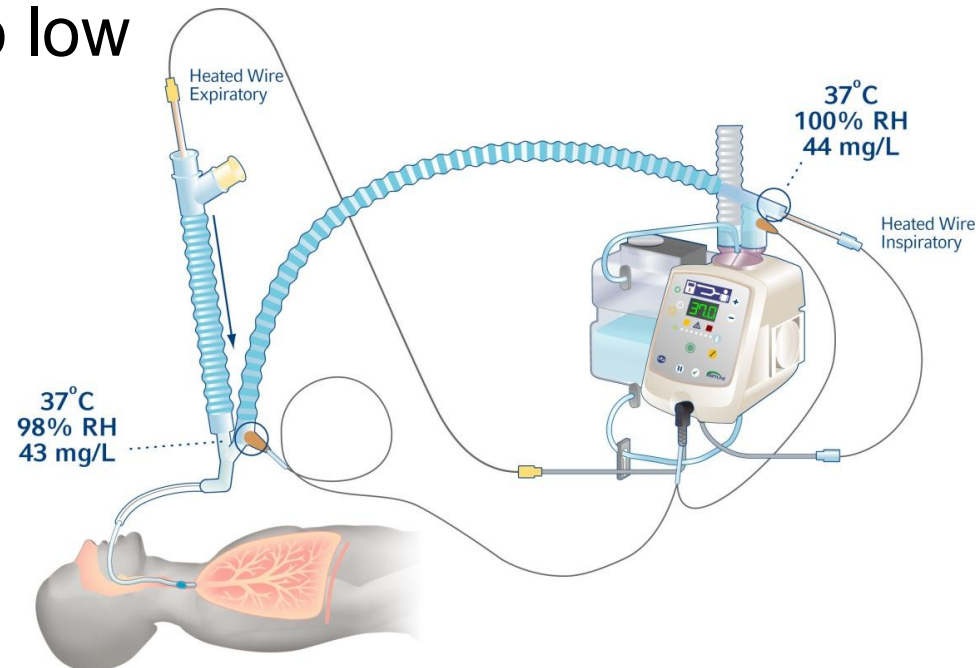
- Active humidifiers use energy and water external to the body for conditioning inspired gas
 - Humidity level between 33 mg H₂O/L and 44 mg H₂O/L¹
 - Gas temperature between 34° C and 41° C at the circuit Y-piece at RH of 100%¹
- Passive humidifiers rely on temperature and humidity gradient between body and external environment
 - HME minimum of 30 mg H₂O/L of delivered gas at 30° C¹

Humidification Device Selection



Active Heated Humidification

- Heated delivery circuit
 - Exit from humidifier- Near 37°C, saturated
 - Travel along circuit- Gas heats; RH drops
- Condensation prevented
- RH may drop too low



Special Conditions Affecting Humidity

- Factors that may affect humidity and circuit temperature include
 - Room temperature
 - Minute ventilation
 - Peak inspiratory flows
 - Ventilator gas outlet temperature
 - Ventilator outlet as well as ambient air temperature could reduce absolute humidity to as low as 20 mg H₂O/L
 - Turbine powered units create additional heat inside the case

HME Humidification and Filtration

- A reduction in the efficiency of humidification performance typically occurs as inspiratory flow, tidal volume, and concentration of oxygen delivery increase.¹
- Even at small tidal volumes, studies demonstrate considerable differences in device performance.¹
- **HME selection should be based on a device that is affordable, lightweight, adds minimal mechanical dead space to the ventilator circuit, and has negligible resistance to gas flow.²**

1. Lucato JJ, et al. *Clinics (Sao Paulo)*. 2009;64(6):585-590.

2. Rathgeber J. *Respir Care Clin N Am*. 2006;12(2):165-182

Comparative Study of Humidifiers

- Lellouche and colleagues (2009) found considerable variance in the filtering and humidifying efficiency of 48 passive humidifiers.
 - Efficiencies varied greatly, ranging from 37.8% to 91.1%.
 - Differences in mechanical dead space were 22 mL to 95 mL.
 - As water load of the HME increased, resistance to flow increased proportionally.
 - Resistance for some were negligible—0.4 cm H₂O/L/s—while other devices imposed a higher resistance of 3.9 cm H₂O/L/s.

Comparative Study of Humidifiers

- Products that allow aerosolized particles to be redirected away from the hygroscopic media (through center of device or through a separate piece of tubing) minimize fluctuations in mean airway pressure and $F_{I}O_{2}$.
- This reduces variations in tidal volume delivery and risk of cross-contamination, which occur with interruptions or breaks in ventilator circuit integrity.^{1,2}



1. Dhand R, et al. *Curr Opin Crit Care*. 2007;4(1):47-61.

2. AARC evidence based clinical practice guideline. *Respir Care*. 2003;48(9):869-879

Patient Considerations when using a HME

- HME use is contraindicated when:
 - bronchopleural fistula or large leak around the cuff
 - uncuffed endotracheal or tracheostomy tube
 - thick, copious, or bloody secretions
 - minute ventilation in excess of 10 L/minute
 - body temperature below 32°C (89.6°F).

Patient Considerations when using a HME

- Patients should be monitored for signs of increased work of breathing, body temperature changes, and alterations in the quality/quantity of airway secretions.
- Inadvertent increase in baseline pressures may be due to increased flow resistance.
- Peak inspiratory pressures during volume-controlled ventilation may increase, along with water load of the device.
- Frequent changes of HMEs may indicate a need to switch to active humidification.

Patient Considerations when using a HME

- Typically, manufacturers recommend HMEs be changed daily.
- However, studies have demonstrated safety and efficacy when used for at least 48 hours.¹
- Prolonging the use of an HME further reduces the risk of cross-contamination and results in considerable cost savings.²

1. Lacherde JC, et al. *Am J Respir Crit Care Med*. 2005;172(10):1276-82.

2. Kola A, et al. *Intensive Care Med*. 2005;31(1):5-11.

Avoiding Manipulation of the ETT

- Avoid changing ventilator circuits unless they are soiled
- Eliminate nonessential endotracheal suctioning
- Use aerosol delivery devices that avoid breaking the circuit

Ventilator Circuit Changes

- **Studies and practice guidelines recommend avoiding unnecessary manipulation and routine changes of the ventilator circuit.¹**
- Longer circuit change intervals were associated with positive patient outcomes:
 - reduction in VAP rate and associated affects on morbidity and mortality
 - reduction of direct and indirect cost of equipment maintenance.^{2,3}

1. Respir Care 2003;48(9):869–879

2. Tolentino-DelosReyes AF, et al. *Am J Crit Care*. 2007;16(1):20-27.

3. Zaydfudim V, et al. *Arch Surg*. 2009;144(7):656-662.

Eliminating Nonessential ETT Suctioning

- A multifaceted program to prevent VAP
 - VAP decreased by 51% after interventions
 - Elimination of nonessential tracheal suction
 - Avoiding ventilator-circuit disconnection and manipulation of the ETT

Maintenance of ETT Cuff Pressures

- Meticulous attention to tracheal seal essential to minimize threat of aspiration
 - Maintain cuff pressures > 20 cm H₂O.^{1,2,3}
- Excessive cuff pressures and inadvertent endotracheal tube migration contribute to mucosal irritation and cellular damage.
- Will reduce leaking of colonized subglottic secretions into trachea and Lower Respiratory Tract
- Remove pooled secretions prior to routine cuff maintenance or manipulation of cuff and endotracheal tube.

1. Rello J, et al. *Am J Respir Crit Care Med*. 1996;154:111-115.

2. Eggimann P, et al. *Crit Care Med*. 2005;33(10):2184-93.

3. *Am J Respir Crit Care Med* 2005; 171:388-416

ETT Modifications

- Tracheal tube designs have been modified to reduce risk of microaspiration and incidence of VAP:
 - addition of a suction channel for intermittent or continuous aspiration of subglottic secretions
 - changes in the cuff design
 - addition of an antimicrobial coating

ETT Modifications

- Subglottic secretion drainage (SSD) for the prevention of VAP: A systematic review and meta-analysis
 - Two perceived barriers to their use: cost and identification of patients who are likely to need MV long before intubation.
 - The number needed to treat for an ETT with SSD to prevent one case of VAP was 11 contrasted with the low acquisition cost of these ETTs and the large amount of costs associated with VAP.

ETT Modifications

- Level 1 (high)- Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia¹
- Coppadoro et al. - Modifying endotracheal tubes to prevent VAP²
 - Modifications of ETTs show promising results
 - Lack of a significant effect on outcomes prompts us to use caution before recommending their widespread use

1. Am J Respir Crit Care Med 2005; 171:388-416

2. Current Opinion in Infectious Diseases 2011, 24:157-162

Safety Concerns

- Outside diameter of tracheal tubes is thicker and more rigid than conventional ETTs.
- Risk for pharyngeal and laryngeal injury may be greater.¹
- Herniation of tracheal mucosa into subglottic suctioning lumen can cause serious tracheal injury
- Risk of microaspiration due to mechanical failure and obstruction of suctioning lumen.²

1. Jaensson M, et al. *Acta Anaesthesiol Scand*. 2010;54(2):147-153.

2. Dragoumanis CK, et al. *Anesth Analg*. 2007;105(4):1083-1085.

ETT Modifications

- Tracheal tube cuff composition and design have been modified to prevent channel formation and microaspiration within inflated cuff.
- In Randomized controlled studies (RCT), tracheal tube cuffs made of polyurethane or silicone decreased incidence of VAP in medical and surgical intensive care units.¹
- Although safety data on polyurethane-cuffed tubes are limited, the literature reports no known theoretical concerns or significant safety issues.

1. Poelaert J, et al. *J Thorac Cardiovasc Surg*. 2008;135(4):771-776.

ETT Modifications

- Silver or silver-sulfadiazine have been used to coat internal lumen of endotracheal tube
- Aim is to reduce secretion accumulation and bacterial growth.
- Evidence is lacking for the use of endotracheal tubes with this type of modification.¹
- Important safety concerns remain regarding the use of some devices
- Cost-effectiveness data are lacking.²

1. Kollef MH, et al. *JAMA*. 2008;300(7):805-813.

2. Deem S, Treggiari MM. *Respir Care*. 2010;55(8):1046-1055.

Hand Hygiene and Glove / Gown Adherence

- Adherence to standard precautions (e.g. hand hygiene, personal protective barriers) can effectively reduce person-to-person transmission of microbial agents.^{1,2}
- Compliance with routine hand washing after contact with mucus membranes, respiratory secretions, or objects contaminated with respiratory secretions is generally low.³⁻⁵
- However, these procedures are very important for preventing cross-contamination and lowering incidence of VAP.⁶

1. Akyol A, et al. *J Hosp Infect.* 2006;62(4):395-405.

2. Hayden MK, et al. *Infect Control Hosp Epidemiol.* 2008;29(2):149-154.

3. Creedon SA. *J Adv Nurs.* 2005;51(3):208-16.

4. Patarakul K, et al. *J Med Assoc Thai.* 2005;88 Suppl 4:S287-93.

5. Creedon SA. *Nurs Times.* 2008;104(49):32-35.

6. Won SP, et al. *Infect Control Hosp Epidemiol.* 2004;24:742-746.

Hand Hygiene and Glove / Gown Adherence

- Level 1 (high)- Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia¹
- Placing a label on the ventilator to remind therapist about hand washing and glove use may improve compliance.

1. Am J Respir Crit Care Med 2005; 171:388-416
2. Khatih M et al. Chest 1999; 116:172-175.

Head of Bed Elevated 30° - 45°

- Level 1 (high)- Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia¹
- Clinicians perceived HOB elevation correctly 50% to 86%.

1. Am J Respir Crit Care Med 2005; 171:388-416
2. Hiner C et al. AJCC. 2010;19:164-167.

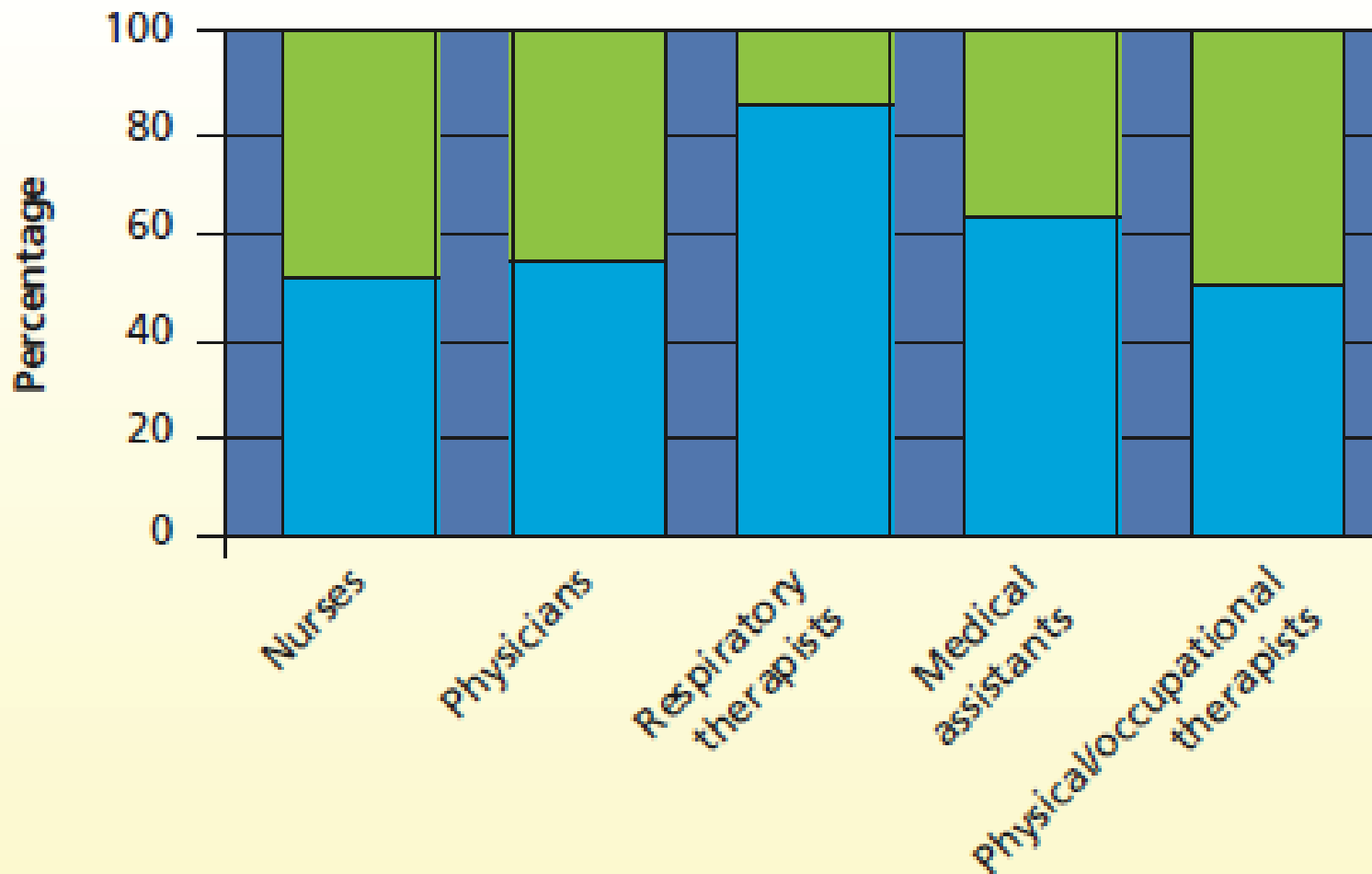


Figure Identification of head-of-bed elevation: correct (blue) vs incorrect (green).

Oral Hygiene

- Dental plaque and oral disease are directly related to colonized oral secretions and contribute to contamination of the LRT through microaspiration.
- A comprehensive oral hygiene program, including twice daily brushing of the teeth and use of an oral chlorhexidine rinse are effective in reducing bacterial colonization of the upper digestive tract and VAP.¹

1. Stonecypher K. *Crit Care Nurs Q.* 2010;33(4):339-47.

Oral Hygiene

- Level 1 (high)- Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia¹
- A multifaceted program to prevent VAP²
 - VAP decreased by 51% after interventions
 - Apply a 0.12% chlorhexidine solution with a foam applicator swab 4 times/day

1. Am J Respir Crit Care Med 2005; 171:388-416
2. Bouadma et al. Crit Care Med 2010

Use of Non-invasive Ventilation

- Level 1 (high)- Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia¹
- Pneumonia associated with invasive and noninvasive ventilation: an analysis of the German nosocomial infection surveillance system database²
 - 400 ICUs with 779,500 admitted patients, 1,068,472 IMV days and 101,569 NIV days
 - 6,869 cases of pneumonia between 2005 and 2007
 - 5,811 cases were associated with (Invasive Mechanical Ventilation (IMV)
 - 160 with Non-Invasive Ventilation (NIV)
 - 898 were not associated with ventilation

1. Am J Respir Crit Care Med 2005; 171:388-416

2. Kohlenberg et al. Intensive Care Med 2010; 36:971-978

Assessment for Daily SBTs

- Awakening and Breathing Controlled Trial
 - 4 tertiary-care hospitals randomly assigned 336 MV pts to management with a daily Spontaneous Awakening Trial (SAT) followed by an Spontaneous Breathing Trial (SBT) (n=168) or with sedation per usual care plus a daily SBT (n=168)
 - Pairing daily spontaneous awakening trials with daily spontaneous breathing trials results in better outcomes and should become routine practice.

	Intervention group (n=167)	Control group (n=168)	p value
Ventilator-free days*			
Mean	14.7 (0-9)	11.6 (0-9)	0.02
Median	20.0 (0 to 26.0)	8.1 (0 to 24.3)	
Time to discharge (days)			
From intensive care	9.1 (5.1 to 17.8)	12.9 (6.0 to 24.2)	0.01
From hospital	14.9 (8.9 to 26.8)	19.2 (10.3 to NA)†	0.04
28-day mortality	47 (28%)	58 (35%)	0.21
1-year mortality	74 (44%)	97 (58%)	0.01
Duration of brain dysfunction (days)			
Coma	2 (0 to 4)	3 (1 to 7)	0.002
Delirium	2 (0 to 5)	2 (0 to 6)	0.50
RASS at first successful SBT	-1 (-3 to 0)	-2.5 (-4 to 0)	0.0001
Complications			
Any self-extubation	16 (10%)	6 (4%)	0.03
Self-extubation requiring reintubation‡	5 (3%)	3 (2%)	0.47
Reintubation‡	23 (14%)	21 (13%)	0.73
Tracheostomy	21 (13%)	34 (20%)	0.06

Data are mean (SD), n (%), or median (IQR). RASS=Richmond agitation-sedation scale. SAT=spontaneous awakening trial. SBT=spontaneous breathing trial. *Ventilator-free days from study day 1 to 28. †Greater than 25% of patients in the SBT group remained in the hospital at study day 28. ‡Reintubation within 48 hours of extubation.

Table 3: Main outcomes

Infection Control- Disinfecting Equipment

- Disinfection practices are essential for preventing VAP:¹
 - Proper disinfection and maintenance of external equipment surfaces
 - Sterilization of non-disposable medical devices
- Minimize microbiological colonization
- Single-use disposable wipes or multi-use spray containers are appropriate.

Infection Control- Disinfecting Equipment

- Clinicians must pay particular attention to:¹
 - The time the cleaning agent is in contact with the ventilation surface
 - Protocol for rinsing and drying the cleansed areas
- Adherence to these procedures is directly related to the efficacy of microbial eradication.¹
- Strict observance of aseptic technique in tracheostomy care is essential, e.g.
 - Cleaning area surrounding the stoma
 - cleaning or changing the inner cannula

1. http://www.cdc.gov/hicpac/pdf/guidelines/disinfection_nov_2008.pdf

Ventilator Bundle

- “Bundling” is a series of interdependent, scientifically grounded, caregiving steps that address a healthcare concern.¹
- The concept of a VAP bundle grew from the Institute for Healthcare Improvement 100,000 Lives campaign, an initiative to reduce VAP incidence.¹
- Continued with the IHI expanded 5 Million Lives campaign.
- Ventilator bundles effectively reduce VAP.²

1. Berwick DM, et al. *JAMA*. 2006; 295(3):324-327.

2. Wip & Napolitano. *Current Opinion in Infectious Diseases* 2009, 22:159–166

Ventilator Bundle

- The ventilator bundle is a set of evidence-based interventions for patients on mechanical ventilation.
- Comprises 5 essential practices:¹⁻⁴
 - Semi-recumbent positioning in which the head of the bed is elevated 45°
 - Daily sedation vacations plus daily assessment of the patient's readiness for extubation
 - Prophylaxis for peptic ulcer disease
 - Prophylaxis for deep vein thrombosis
 - Daily oral care with chlorhexidine.

1. DePalo VA, et al. *Qual Saf Health Care*. 2010;19(6):555-561.

2. Bird D, et al. *Arch Surg*. 2010;145(5):465-470.

3. Collard HR, et al. *Ann Intern Med*. 2003;138(6):494-501.

4. Institute for Healthcare Improvement Web site. Implement the IHI Ventilator Bundle.

Conclusions

- Ventilator-associated pneumonia is a frequent complication in patients receiving invasive mechanical ventilation.
- HAI causes increased patient morbidity and mortality, and increases the burden of care in terms of direct and indirect financial costs.
- Accurate clinical diagnosis of VAP can be problematic but is an essential component of care.
 - New definitions in VAC and IVAC

Conclusions

- Hand Hygiene and Glove / Gown Adherence / Infection control adherence are key components.
- Head of Bed elevated 30 degrees or greater can reduce VAP.
- RTs can assist with oral hygiene to reduce VAP.
- Use of Non-invasive Ventilation can significantly impact VAP.
- Combined Daily SATs and SBTs can improve outcomes.

Conclusions

- Maintain ETT cuff pressures between 20 and 25 cmH₂O.
- Endotracheal tubes with subglottic secretion drainage appear to be beneficial although potential complications are concerning.
- Avoiding manipulation of the ETT and breaking the circuit
 - No routine suctioning
 - No circuit changes unless soiled
 - Use MDIs or devices that do not require breaking the circuit
 - Use a HME that does not need to be changed every 24hrs.



Thank you for your attention!