Successful Reduction of Ventilator-Associated Pneumonia

Introduction

Intensive care unit (ICU) patients, due to their critical illnesses and compromised immunity, are at high risk for healthcare-associated infections (HAIs). The overall infection rate in critically ill patients approaches 40%, as reported by Girou et al., and may be as high as 50% or 60% in patients who remain in the ICU for more than 5 days, as discussed in a study conducted by Bueno-Cavanillas et al.1-3 The incidence of ICU-acquired pneumonia ranges from 10% to 65%.3 Ventilator-associated pneumonia (VAP) is defined as healthcare-associated pneumonia in a patient who is on mechanical ventilatory support (by endotracheal tube or tracheostomy) for more than 48 hours.4 Patients at high risk for VAP include those who have chronic obstructive pulmonary disease, burns, neurosurgical conditions, acute respiratory distress syndrome, and witnessed aspiration; those who are reintubated; and those who receive paralytic agents or enteral nutrition.5

A prospective study conducted by Ibrahim et al. for 22 months in a 500-bed community nonteaching hospital showed that 15% of mechanically ventilated patients developed VAP. Approximately 34% of patients who received mechanical ventilation died during hospitalization. The study further revealed that the following factors were independently associated with patients who developed VAP: tracheostomy, multiple central venous line insertions, reintubation, and the use of antacids, which neutralize the ability to kill bacteria in the stomach. The hospital mortality of patients with VAP was significantly greater than the mortality of patients without VAP (45.5% versus 32.2%, respectively).6 In a retrospective matched cohort study using data from a large U.S. inpatient database, Rello et al. found that patients with VAP remained in the ICU approximately 6 days longer than patients who did not have VAP (11.7 ± 11 days versus 5.6 ± 6.1 days) and had significantly longer durations of mechanical ventilation (14.3 ± 15.5 days versus 4.7 ± 7 days) than those patients who did not have VAP.7

**Targeting Zero Infections**

In 2005, the Institute for Healthcare Improvement (IHI) launched the 100,000 Lives Campaign, which evolved into the 5 Million Lives Campaign, with the goal of protecting patients from 5 million incidents of medical harm between December 2006 and December 2008. The campaign involved a nationwide effort to reduce mortality and morbidity associated with hospital care by recruiting healthcare institutions to implement process measures. This included measures to prevent VAP through implementation of evidence-based practices, including the ventilator bundle. The ventilator bundle is a series of evidence-based interventions related to ventilator care that, when implemented together with ongoing compliance, will achieve significantly better outcomes than when implemented individually.8

Components of the ventilator bundle include the following:

- Elevation of the head of the bed (HOB) between 30 and 45 degrees
- Daily “sedation vacation” (i.e., lightening or weaning of sedation for the purpose of allowing patients to assist themselves to breathe and hence be ready for extubation as soon as possible)
- Daily assessment for readiness to extubate
- Peptic ulcer disease (PUD) prophylaxis
- Deep vein thrombosis (DVT) prophylaxis

For more information, see the sidebar “Components of the Ventilator Bundle.”

The Association for Professionals in Infection Control and Epidemiology (APIC) has been instrumental in providing education and guidance to prevent the most common HAIs as part of its “Targeting Zero” initiative through Webinars, conferences, and tools in the form of elimination guides for certain HAIs. These elimination guides have been developed using Centers for Disease Control and Prevention (CDC) recommendations for infection prevention for healthcare workers. The infection control community is awaiting publication of a new VAP elimination guide, due for release in 2009.

In an effort to reach “zero,” many hospitals in Pennsylvania have employed ventilator bundles during the past few years. Of note are two hospitals that have been successful in reducing their VAP rates and maintaining very low or zero rates by consistent application of risk reduction strategies. This article addresses implementation of the ventilator bundle and the subsequent significant positive results at these two hospitals. Hospital personnel, including the infection preventionists, were contacted and interviewed directly. They provided written reports and documentation of their programs, results, and successes.

**Roxborough Memorial Hospital**

Roxborough Memorial Hospital (RMH) is a 137-bed community teaching hospital in Philadelphia. RMH includes a nursing school as well as a residency program for the Philadelphia College of Osteopathic Medicine.

**Problem**

During 2003, the 10-bed combined medical-surgical ICU identified 10 cases of VAP, and in 2004, the number rose to 12. At that time, the hospital was not reporting total ventilator-days, and benchmarking against the National Healthcare Safety Network (NHSN) was not possible. However, internal rate...
# Components of the Ventilator Bundle

## Elevation of the Head of the Bed

Elevation of the head of the bed is an integral part of the ventilator bundle and has been correlated with reduction in the rate of ventilator-associated pneumonia (VAP). The recommended elevation is 30 to 45 degrees.

## Daily “Sedation Vacations” and Assessment of Readiness to Extubate

It appears that lightening sedation decreases the amount of time spent on mechanical ventilation and therefore the risk of VAP. In addition, weaning patients from ventilators becomes easier when patients are able to assist themselves during extubation with coughing and control of secretions. However, sedation vacations are not without risks. Patients who are not sedated as deeply will have an increased potential for self-extubation. Therefore, extubation must be conducted carefully.

## Peptic Ulcer Disease Prophylaxis

Applying peptic ulcer disease prophylaxis is an appropriate intervention in all patients who are sedentary; however, the higher incidence of stress ulceration in critical illness justifies greater vigilance. In addition, decreasing the pH of gastric contents may protect against a greater pulmonary inflammatory response to aspiration of gastrointestinal contents. Critically ill intubated patients lack the ability to defend their airway. While it is unclear whether there is any association with decreasing rates of VAP, experience has shown that when applied as a package of interventions for ventilator care, the rate of pneumonia decreases precipitously. The intervention remains excellent practice in the general care of ventilated patients.

## Deep Vein Thrombosis Prophylaxis

Applying deep vein thrombosis (DVT) prophylaxis is an appropriate intervention in all patients who are sedentary; however, the higher incidence of DVT in critical illness justifies greater vigilance. The risk of venous thromboembolism is reduced if prophylaxis is consistently applied.

### Source:

contains a compilation of recognized practices. IHI’s incorporation of several key measures in the ventilator bundle that accompanies its campaigns has further established best practices with regard to preventing VAP. These tools are readily available to all healthcare organizations that provide care for patients at risk for VAP.

At RMH, the multidisciplinary input of the ICU committee was key to the successful development and implementation of the VAP protocol. Support from physician leaders, particularly those practicing in the ICU, was essential. The ICU nurse manager and the hospital’s infection control practitioner provided the necessary hands-on dedication to the task. The process of changing nursing routine in a busy ICU was daunting, but the combination of high-quality background data, rigorous monitoring, and ongoing education contributed to the success of the project. Finally, an evolving sense of pride at all levels of hospital management about the staff’s accomplishments reinforced the efforts and provided the necessary leadership support to maintain success.

St. Christopher’s Hospital for Children

St. Christopher’s Hospital for Children is a 189-bed pediatric teaching hospital located in Philadelphia. St. Christopher’s has a Level I trauma center, a burn center, and a level III neonatal intensive care unit (NICU).

Problem

During 2006, St. Christopher’s identified that the VAP rate in its NICU was high in comparison to the NHSN NICU pooled mean rates. Its baseline VAP rate was 3.9 per 1,000 ventilator-days in 2006. The NHSN neonatal pooled mean ranges from 0.8 to 3.3, depending on birth weight.

Further evaluation revealed inconsistent clinician knowledge and practice related to VAP prevention. At the time that this increased rate was discovered, ventilator bundling was beginning to gain popularity in the adult population, but scientific evidence was lacking regarding its use in neonates. St. Christopher’s assembled a multidisciplinary team to undertake the following:

- Analyze current practice.
- Identify opportunities for improvement.
- Identify new evidence, including best practices.
- Develop a process for ongoing evaluation of VAP prevention elements.

### Table. Baseline Assessment of ICU Nursing Measures at Roxborough Memorial Hospital, October through December 2004

<table>
<thead>
<tr>
<th>ELEMENTS</th>
<th>COMPLIANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform oral care every four hours</td>
<td>Not always</td>
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<tr>
<td>Suction oral cavity and back of mouth as needed</td>
<td>Yes</td>
</tr>
<tr>
<td>Perform oral suctioning before deflating the endotracheal cuff</td>
<td>Yes</td>
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<tr>
<td>Aspirate for gastric residual, if on enteral feeding</td>
<td>Yes</td>
</tr>
<tr>
<td>Turn patient every two hours</td>
<td>Not always</td>
</tr>
<tr>
<td>Move patient out of bed every eight hours if stable</td>
<td>Not always</td>
</tr>
<tr>
<td>Evaluate and describe secretions at least every four hours</td>
<td>Yes</td>
</tr>
<tr>
<td>Drain and dispose of condensation from the ventilator</td>
<td>Yes</td>
</tr>
<tr>
<td>Notify physician of changes in secretions and any suspected/witnessed aspiration</td>
<td>Yes</td>
</tr>
<tr>
<td>Clean, sterilize, and disinfect reusable equipment</td>
<td>Yes</td>
</tr>
<tr>
<td>Engage in handwashing before ventilator contact</td>
<td>Not always</td>
</tr>
<tr>
<td>Change ventilator circuits and inline suction catheters only when visibly soiled or malfunctioning</td>
<td>Yes</td>
</tr>
<tr>
<td>Maintain adequate ventilation and cuff pressure</td>
<td>Yes</td>
</tr>
<tr>
<td>Drain condensate from the ventilator circuit using appropriate technique to avoid contamination of the circuit</td>
<td>Yes</td>
</tr>
<tr>
<td>Change humidifier every 24 hours</td>
<td>Yes</td>
</tr>
<tr>
<td>Ensure that ventilator circuits are not unnecessarily broken</td>
<td>Not always</td>
</tr>
<tr>
<td>Elevate head of bed 30 to 45 degrees at all times</td>
<td>Not always</td>
</tr>
<tr>
<td>Practice daily sedation vacation</td>
<td>No</td>
</tr>
<tr>
<td>Conduct daily assessment of readiness to extubate</td>
<td>Not daily</td>
</tr>
<tr>
<td>Institute peptic ulcer disease prophylaxis protocol</td>
<td>No</td>
</tr>
<tr>
<td>Institute deep vein thrombosis prophylaxis protocol</td>
<td>Not always</td>
</tr>
<tr>
<td>Track ventilator-associated pneumonia (VAP) cases and device-days</td>
<td>Yes</td>
</tr>
<tr>
<td>Provide staff education relative to VAP prevention</td>
<td>Yes</td>
</tr>
<tr>
<td>Identify high-risk patients</td>
<td>Yes</td>
</tr>
<tr>
<td>Place high-risk patients on an intensive VAP prevention protocol</td>
<td>No</td>
</tr>
</tbody>
</table>
The team modified its previous ventilator bundle to include the neonatal population.

Characteristics of 27 NICU VAP patients from 2005 through 2007 revealed that the typical VAP patient in the NICU was less than 35 weeks' corrected gestational age, was intubated for more than 3 weeks on conventional ventilation before VAP occurred, had a length of stay less than 1 month before VAP diagnosis, and was infected with organisms known to cause HAIs. Predominant VAP organisms included *Pseudomonas aeruginosa* (38%, n=8), *Klebsiella pneumoniae* (33%, n=7) and *Staphylococcus aureus* (29%, n=6); of the last, 50% of the cases were methicillin-resistant.

**Outcomes**

Following a literature review and networking with other pediatric hospitals, the multidisciplinary team implemented a series of revisions to an existing pediatric ventilator bundle to better serve the neonate population. The resulting elements are called PREVENT (see the sidebar “Elements of the Revised Ventilator-Associated Pneumonia Bundle [PREVENT]—St. Christopher’s Hospital for Children”).

Some of the changes included the following:

- Elevating HOB 15 to 30 degrees for NICU patients
- Using neonatal oral hygiene care kits for patients of more than 25 weeks’ gestational age
- Implementing neonatal oral hygiene with sterile water for patients of less than 25 weeks’ gestational age
- Securing endotracheal tubes using standard procedures
- Discarding all tubing and circuits from standby ventilators
- Altering the frequency of ventilator circuit, tubing, and disposable oxygen equipment changes
- Adopting a standard for depth of suctioning and suction pressures
- Implementing a patient flow sheet to document completion of bundle elements

Following implementation of the bundle, the VAP rate decreased by 60% to 1.5 per 1,000 ventilator-days in 2007 and 0.3 in 2008. The following further summarizes the results of implementation:

- The NICU VAP infection rate (number of VAP cases/1,000 ventilator-days) decreased to 0.3 (1/3,396) in 2008 as compared with 1.5 (4/2,641) in 2007 and 3.9 (10/2,523) in 2006. (See Figure 2.)
- Following implementation of the bundle, the NICU had zero cases of VAP between June 2007 and December 2008 (see Figure 3).
- NICU hand hygiene compliance, a bundle component, continued to increase after implementation of the revised ventilator bundle (see Figure 4). NICU staffing ratios increased from 13.5 hours per patient-day in 2006 to 15 in 2007 and remained at 15 hours in 2008.

**Commentary**

Development and implementation of the modified neonatal ventilator bundle (PREVENT) resulted in improvement in practices and a significant and sustained decrease in NICU VAP. The initiative required the skill, knowledge, and dedication of nurses, physicians, infection preventionists, and respiratory therapists. As seen with a number of HAI reduction and prevention programs, a multidisciplinary team approach was key to the success of this initiative.

(continued on page 68)
**Elements of the Revised Ventilator-Associated Pneumonia Bundle (PREVENT)—St. Christopher’s Hospital for Children**

**Practice Meticulous Hand Hygiene**
Perform hand hygiene by washing with soap and water and using friction for at least 15 full seconds, or use an alcohol-based hand sanitizer (unless hands are visibly soiled or the patient has *Clostridium difficile*).

**Remember Barrier Precautions**
Barrier precautions include the following:
- Wear gloves when
  - performing intubation or manipulation of the airway,
  - opening the ventilator circuit (i.e., to manually ventilate, to drain fluid from the circuit, to open or replace the in-line suction system),
  - performing respiratory procedures, or
  - handling respiratory secretions or objects potentially contaminated with respiratory secretions.
- Wear a surgical mask and eye protection when performing high-risk respiratory procedures or when within three feet of a coughing or sneezing patient.
- Wear a gown when soiling with respiratory secretions is anticipated. Change gown before providing care to another patient.

**Elevate the Head of Bed**
This element includes the following:
- Elevate the head of bed (HOB) 15 to 30 degrees for neonates (less than 28 days old) and 30 to 45 degrees for older patients, unless contraindicated.
- Reposition patient every two to four hours, unless contraindicated.
- Document HOB elevation and times of repositioning on flow sheet.

**Vigilant Oral Hygiene**
The registered nurse initiates the patient assessment by evaluating the endotracheal tube and completing oral care.

Oral hygiene includes the following:
- Brushing of teeth every 12 hours (as applicable)
- Cleansing and suctioning the oral cavity every four hours (between brushing) and as needed
- Hypopharyngeal suctioning

**Effective but Minimal Sedation/Extubation Readiness**
- Avoid constant heavy sedation.
  - Use minimal but effective sedation.
- Avoid neuromuscular blockade.
- Assess/document level of sedation every four hours.
- Assess readiness for extubation (by a physician or designee) at least daily.

**Need for Friendly Reminders**
Prevention of infection is the responsibility of all healthcare workers.
- Offer a friendly reminder if someone is not following precautions/procedures of the ventilator bundle.
- Accept reminders as courteously as they are given.

**Techniques for Proper Suctioning and Ventilator/Supply Management**
Various techniques for suctioning and maintenance of ventilators/supplies have been instituted in conjunction with policies and procedures specific to the neonatal intensive care unit. These procedures are summarized below:
- Perform endotracheal tube suctioning as needed (i.e., not routinely performed at regular intervals).
  - Use nonsterile gloves for a suction catheter within a closed sheath (i.e., closed in-line suctioning) or for tracheostomy care.
  - Use sterile technique, including sterile gloves, if a closed suction system or the ventilator circuit requires opening.
  - Place a “safe suctioning” card at patient bedside at the time of intubation to indicate proper depth of endotracheal tube suctioning in a closed system.
  - Maintain closed suction setups and in-line suctioning as much as possible. If opening is required, the tip of suction catheter and tubing end should be kept sterile at all times when disconnected.
  - Open normal saline ampules with an alcohol pad and clean gloves if suctioning with saline is ordered.
  - Provide appropriate suction pressures according to intensive care unit protocol.
  - Maintain ventilator circuit lower than the patient to prevent water lavage to patient.
- Key factors in ventilator and supply management include the following:
  - Perform hand hygiene.
  - Maintain sterile technique when opening a closed suction system.
  - Keep supplies that enter or connect to suction or ventilator circuit sterile.
  - Maintain nonsterile supplies in the cleanest way possible.
Ongoing evaluation and celebration of successes are imperative to sustaining changes in practice and culture.

A representative sample review of utilization of oral care kits demonstrated a 31% increase of kit usage and a 74% increase in documentation of oral hygiene after implementation of the revised ventilator bundle; St Christopher’s attributes this to infection control feedback to the nursing units and the persistence of the NICU team with implementing the change.

**Conclusion**

The key to sustained success for reduction of VAP as demonstrated by Pennsylvania’s Roxborough Memorial Hospital and St. Christopher’s Hospital for Children includes a multidisciplinary approach to implementing evidence-based risk reduction strategies. In addition, using various resources such as the CDC guidelines, IHI ventilator bundles, and APIC guides for prevention of infection, in combination with ongoing monitoring, education, and feedback, resulted in reduction of these infections. It has been clearly demonstrated that pride and ownership by staff members are additional key contributing factors to ongoing success when “targeting zero.”

**Notes**


