Feature

Using Evidence-Based Practice to Prevent Ventilator-Associated Pneumonia

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BACKGROUND Strategies are needed to help prevent ventilator-associated pneumonia.

OBJECTIVE To develop a ventilator bundle and care practices for nurses in critical care units to reduce the rate of ventilator-associated pneumonia.

METHOD The ventilator bundle developed by the Institute for Healthcare Improvement was expanded to include protocols for mouth care and hand washing, head-of-bed alarms, subglottic suctioning, and use of an electronic compliance feedback tool. Compliance audits were used to provide immediate electronic feedback.

RESULTS Adherence to practices included in the bundle increased. Compliance rates were greater than 98% for prophylaxis for peptic ulcer disease and deep-vein thrombosis, interruption of sedation, and elevation of the head of the bed. The compliance rate for the oral care protocol increased from 76% to 96.8%. Readiness for extubation reached at least 92.4%. Rates of ventilator-associated pneumonia decreased from 9.47 to 1.9 cases per 1000 ventilator days. The decrease in rates produced an estimated savings of approximately $1.5 million.

CONCLUSION Strict adherence to bundled practices for preventing ventilator-associated pneumonia, enhanced accountability for initiating protocols, use of a feedback system, and interdisciplinary collaboration improved patients' outcomes and produced marked savings in costs. (*Critical Care Nurse.* 2012;32[4]:41-51)

CNE Continuing Nursing Education

This article has been designated for CNE credit. A closed-book, multiple-choice examination follows this article, which tests your knowledge of the following objectives:

1. List the components of the 2010 Institute for Healthcare Improvement ventilator bundles
2. Discuss the financial implications of patients developing ventilator-associated pneumonia
3. Identify strategies to help implement ventilator bundles successfully in a hospital

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Health care–associated infections (HAIs) are the most common complications in hospitalized patients.[1] Ventilator-associated pneumonia (VAP) is the second most common HAI in the United States and is responsible for 25% of the infections that occur in intensive care units (ICUs).[2] VAP is associated with increases in death rates, length of stay, and health care costs.[3] The death rate for VAP exceeds the rate of death due to infections associated with central vascular catheters, severe sepsis, and respiratory tract infections in nonintubated patients.[4,5] Among patients treated with mechanical ventilation, mortality rates are 46% in patients with VAP and 32% in those without VAP.[6] The cost of care for a patient with VAP is approximately $40 000 to $57 000 higher per occurrence than the cost of care of a patient treated with mechanical ventilation in whom VAP does not develop.[6] Additionally, patients in whom VAP develops stay in the ICU 4 to 19 days longer than do patients who were intubated and did not acquire VAP.[5]

The Centers for Medicare and Medicaid Services[7] recently listed VAP as one of the "reasonably preventable diseases" leading to increased morbidity, mortality, and health care costs. Because the centers view VAP and other HAIs as preventable, soon hospitals may not be reimbursed for care provided to patients

in whom VAP and other HAIs, such as infections caused by methicillin-resistant *Staphylococcus aureus* or associated with vascular catheters, develop.[8] If reimbursement for VAP is discontinued, hospitals will experience a profound economic deficit.

Patients at risk for VAP present a unique challenge to critical care nurses. To prevent VAP, nurses must develop strategies to incorporate evidence-based practices into the daily care provided to patients receiving mechanical ventilation. In this article, we describe an innovative project in which ventilator bundles (a structured way of improving the process of care or patients' outcomes; straightforward evidence-based practices that when performed collectively and reliably improve patients' outcomes[9]) developed by the Institute for Healthcare Improvement (IHI) and care practices developed by nurses in our critical care units were used to reduce VAP rates and enhance the quality of care and well-being of patients receiving mechanical ventilation.

Etiology of VAP

The Centers for Disease Control and Prevention[10] define VAP by using a combination of radiological, clinical, and laboratory criteria. VAP is suspected when a patient receiving mechanical ventilation has evidence of a new or progressive pulmonary infiltrate along with fever, leukocytosis, and purulent tracheobronchial secretions. Pneumonia is considered ventilator associated if the patient was intubated and receiving mechanical ventilation at the time of or within 48 hours before the onset of infection.

According to an expert panel from the American Thoracic Society,[11] placement of an endotracheal tube can potentially increase the risk of VAP 6- to 20-fold in patients treated with mechanical ventilation. For VAP to develop, microorganisms must gain access to the normally sterile lower part of the respiratory tract. Critically ill patients are at risk for microorganisms getting into the lower part of the tract because these patients have a depressed level of consciousness and an impaired gag reflex, which may lead to pooling of approximately 100 to 150 mL of contaminated secretions within the oropharynx within a 24-hour period. Placement of an endotracheal tube impedes the body's natural defense against infection by negating effective cough reflexes and mucocilliary clearance of secretions.[12] Impairment of the cough reflex, accumulation of contaminated secretions within the oropharynx, and placement of an endotracheal tube substantially increase the risk for VAP in critically ill patients.

Review of the Literature

In 2005, the IHI disseminated its first report on the 100 000 Lives Campaign, a project that involved the use of ventilator bundles to prevent VAP. In May 2010, the institute reported the results of an updated project, the 5 Million Lives Campaign. Included in both campaigns were recommendations for best practices or bundles that could be used to reduce VAP rates.[13] Components of the 2010 bundle included elevation of the head of the bed (HOB) 30° to 45°, prophylaxis for peptic ulcer disease (PUD), prophylaxis for deep-vein thrombosis (DVT), daily interruption of sedation, daily assessment of readiness for extubation, and daily oral care with chlorhexidine. Several investigators[9,14,15] examined the efficacy of the IHI bundled practices and found that bundled practices were effective in reducing the rate of VAP.

HOB Elevation

Metheny et al[16] examined the effects of HOB elevation in the prevention of VAP in a prospective study of 360 trauma patients. In that study, the incidence of pneumonia, determined by using the Clinical Pulmonary Infection Score (calculated by using body temperature, white blood cell count, assessment of tracheal secretions, oxygenation, ratio

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of Pao_2 to fraction of inspired oxygen, findings on chest radiographs, and results of cultures of tracheal aspirates; scores of 6 or higher indicate pneumonia), increased from 24% on day 1 of mechanical ventilation to 48% by day 4 of mechanical ventilation. Patients with pneumonia on day 4 (42.2%) had significantly more pepsin-positive tracheal secretions than did patients without pneumonia (21.1%; $P < .001$). In addition, low backrest elevation (≤30°) was a significant risk factor for aspiration ($P = .02$) and pneumonia ($P = .02$).

Grap et al[17] conducted a descriptive study of 66 patients treated with mechanical ventilation in a medical ICU to determine the relationship between backrest elevation and the development of VAP. Data were obtained from laboratory results and medical records from the start of mechanical ventilation up to day 7 of mechanical ventilation. Backrest elevation was continuously monitored by using a transducer system. Backrest elevations were less than 30° 72% of the time and less than 10° 39% of the time. Mean backrest elevation for the entire study period was 21.7°. The researchers[17] concluded that spending the majority of time at a backrest elevation less than 30° and severity of illness affected the incidence of VAP. In a randomized clinical trial reported by Drakulovic et al,[18] among patients receiving mechanical ventilation, 39 were assigned to a semirecumbent position (45°) and 47 to a supine position. The patients in a semirecumbent body position had a lower frequency and risk for nosocomial pneumonia, specifically patients who received enteral feedings, and 18% fewer confirmed cases of pneumonia ($P = .02$).

DVT and PUD Prophylaxis

Prophylaxis to reduce DVT and PUD are the second and third aspects of the VAP bundle. Both DVT prophylaxis and PUD prophylaxis have been considered standard practices in critical care units for many years. Because patients treated with mechanical ventilation are essentially sedentary, DVT prophylaxis with administration of antithrombotic medications and/or use of antiembolism stockings is warranted.[19] PUD prophylaxis is needed to combat the stress of being treated with mechanical ventilation. By providing medications such as $histamine_2$ blockers to increase the pH of gastric contents and defend the airway against acidic contents, patients can be protected against a pulmonary inflammatory response due to aspiration, and their risk for VAP can be lowered.[13]

Interruption of Sedation and Readiness for Extubation

Daily interruptions of sedation and daily assessment of readiness for extubation are other integral components of the ventilator bundle. Traditionally, critical care physicians attempted to minimize the duration of mechanical ventilation by manipulating ventilator modes and slowly decreasing ventilatory support. However, research has revealed that management of sedation can have a more profound effect on the duration of mechanical ventilation and other patient outcomes than can manipulating ventilator modes.[1] In a multicenter, randomized control trial described by Girard et al,[20] paired spontaneous awakening trials (daily interruption of sedatives) were compared with spontaneous breathing trials. A total of 336 patients at 4 tertiary care hospitals who were treated with mechanical ventilation were included in the study. Of these, 168 had daily spontaneous awakening trials followed by a spontaneous breathing trial; the other 168 patients, the control group, had sedation per usual care plus a daily spontaneous breathing trial. The primary study end point was time breathing without assistance. Patients in the intervention group spent more days breathing without assistance during the 28-day study period than did patients in the control group (14.7 days vs 11.6 days; 95% CI, 0.7-5.6; $P = .02$) and were discharged from the ICU at a median time of 9.1 vs 12.9 days ($P = .01$). Girard et al[20] concluded that for every 7 patients treated with the intervention, 1 life was saved (number needed to treat, 7.4; 95% CI, 4.2-35.5). The researchers also suggested that a wake-up-and-breathe protocol paired with daily spontaneous awakening trials (interruption of sedation) and daily spontaneous breathing trials resulted in better outcomes for patients receiving mechanical ventilation than did current standard approaches.

In another study, Schweickert et al[21] performed a retrospective chart review of a database from a previous trial of 128 patients treated with mechanical ventilation who were randomized to daily interruption of sedative infusions or to usual care. They found that patients who had daily interruption of a sedative infusion experienced significantly fewer complications (13 complications; 2.8%) than did patients treated with conventional sedation

techniques (26 complications; 6.2%; $P = .04$). They concluded that interruption of sedation in critically ill patients undergoing mechanical ventilation reduced ICU length of stay and in turn decreased the incidence of complications of critical illness associated with prolonged intubation.

Oral Care

Microbes colonizing the mouth markedly increase the risk for VAP.[19] Pathogens linked to VAP in orally intubated patients become colonized in dental plaque and in the oral mucosa. Within 48 hours of admission to an ICU, patients have changes in the oral flora, which predominantly include gram-negative and other virulent organisms.[22] In addition, dental plaque can provide an environment for respiratory pathogens such as methicillin-resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa*.[17]

Results from a meta-analysis[23] of 11 trials that included 3242 patients receiving mechanical ventilation who were treated with oral application of antibiotics or antiseptics or with placebo or standard oral care alone indicated that the incidence of VAP was significantly reduced by use of oral antiseptics, such as chlorhexidine (relative risk, 0.56; 95% CI, 0.39-0.81), but not by oral applications of antibiotics (relative risk, 0.69; 95% CI, 0.41-1.18). In a study of 66 patients treated with mechanical ventilation, Munro et al[24] examined the relationship between VAP, oral health status (a baseline count of decayed, missing, and filled teeth; an assessment of the oral cavity; culture of an oral specimen; measurement of salivary volume; and salivary levels of the immune components immunoglobulin A and lactoferrin), changes in oral health status during the first 7 days after intubation, and microbial colonization of the oropharynx and trachea. Data on oral health and Clinical Pulmonary Infection Scores were collected at baseline, day 4 (n = 37), and day 7 (n = 21). A regression model was used to predict risk of pneumonia at day 4.

Results indicated that the amount of dental plaque and the number of oral organisms increased over time. Correlations were significant for baseline and day 4 dental plaque ($P < .001$), baseline salivary level of lactoferrin and day 4 plaque ($P = .01$), and lower salivary volume and higher Clinical Pulmonary Infection Scores. The authors[24] concluded that higher dental plaque scores indicate a greater risk for VAP. In addition, they proposed that salivary volume and salivary level of lactoferrin, which influences oropharyngeal colonization, may also affect the risk for VAP.

Evidence-based clinical practice guidelines to reduce VAP have been available for several years. Unfortunately, widely published guidelines do not always bring about changes in behavior. Because clinicians are not consistently incorporating the evidence into their practice, VAP continues to be an important health care challenge.

Methods

This project was conducted in the ICUs at Lankenau Hospital, Main Line Health System, Wynnewood, Pennsylvania, a suburb of Philadelphia. A total of 105 staff nurses were employed on the units at that time. A total of 4709 ventilator days were audited for the project from January 2009 through December 2009.

Design

The process of reducing the number of cases of VAP in the ICUs began in July 2008. An interdisciplinary team consisting of nurses, physicians, and respiratory therapists shared roles and responsibilities for implementing the project. Members of the staff were educated about each aspect of the VAP bundle. Nurses, physicians, and therapists were given fact sheets describing the VAP bundle and the importance of VAP as it related to patients' outcomes and cost of care. "ZAP VAP" signage was placed at every patient bedside. Compliance data were collected from October 2008 through December 2009.

Compliance audits were done by personnel from the quality department. The decision to use these personnel was based on 2 factors. First, the interdisciplinary team thought that having an auditor from outside the nursing department would help eliminate bias in reporting audit findings. Second, the team did not want to disrupt patient care by having nurses pulled away from the bedside to conduct audits. Because members of the nursing department were collaborating with members of other departments to address VAP, the team was able to negotiate with the quality department, and a member of that department's existing staff conducted the audits.

In order to increase the likelihood of success, the SMART approach described by Kollef[25] was used. The SMART approach includes specific, measurable, achievable, relevant, and time-bound approaches to address HAIs. Kollef recommended that nurses and other involved care providers choose specific objectives

that precisely define and quantify desired outcomes, such as reducing the rate of HAIs in an ICU by 25%. He indicated that managers should monitor staff adherence to infection prevention protocols and provide feedback about how well the staff members complied with established guidelines. Kollef advocated having adequate resources to support the team and ongoing communication to reinforce educational tactics.

Implementation of the SMART approach included providing specific directions to all personnel on the steps needed to implement each aspect of the VAP bundle. The interdisciplinary team established measurable goals for success: to achieve 100% compliance with the VAP bundle and to reduce the rate of VAPs to 0. In order to meet the goals, staff members were provided with resources such as checklists, flagged order sheets, and consistent feedback. Finally, the team decided that the time allowed to meet the goals would be 1 year.

The VAP Bundle

The VAP bundle adopted at Lankenau Hospital differed from the IHI bundle (see Table).

Hand-Washing Protocol. Hand washing can reduce the frequency of HAIs, but health care workers rarely achieve greater than 50% compliance with guidelines for hand washing and other infection control measures.[26] Washing and decontaminating hands before and after contact with patients and wearing gloves are important actions in the prevention of VAP.[27,28] Trick et al[27] determined risk factors for hand contamination and compared the efficacy of 3 randomly allocated hand hygiene agents in a group of health care workers, mostly nurses. Specimens for culture were obtained from one hand before hand hygiene and from the other hand after hand hygiene was performed. Ring wearing was associated with a 10-fold higher risk of skin organism counts and contamination with *S aureus*, gram-negative bacilli, or *Candida* species. In addition, use of an alcohol-based hand rub resulted in significantly less frequent hand contamination.

A wash-glove-wash protocol was established by the nursing staff at Lankenau Hospital on the basis of evidence from hand-washing studies.[27,29,30] Adherence to this protocol was determined on a monthly basis. Random monthly observations of hand washing were conducted by personnel selected by the quality department.

HOB Alarms. Nurses' compliance with the recommendation that the HOB remain elevated higher than 30° was enhanced by installing alarms on all beds in the critical care areas. Adherence to this aspect of the protocol was determined via documentation on the chart that the HOB was elevated more than 30°.

Mouth-Care Protocol. The mouth-care protocol was developed in collaboration with the respiratory therapy department. The old protocol consisted of mouth care every 4 hours with toothettes. With the new protocol, mouth care was done every 2 hours or 12 times in 24 hours. The decision to increase mouth care to every 2 hours was based on the studies of oral health and the development of VAP.[12] The mouth-care protocol was accomplished by alternating responsibility for mouth care between respiratory therapists and nurses. Each patient's teeth were brushed at 8 AM and 8 PM with chlorhexidine, and the mouth was cleansed with tooth sponges 10 times per day. Respiratory therapists and nurses discussed this protocol at length and decided that they would share in implementing the protocol to conserve resources. Documentation in the medical record of completion of the protocol was used for the audit.

DVT and PUD Prophylaxis. Physicians were expected to complete a DVT screening tool and use the results to order antithrombotic therapies. They also used standardized orders for DVT and PUD prophylaxis. Flagged notices in each patient's medical record were used to remind physicians to write orders for DVT prophylaxis and PUD prophylaxis. Compliance with this aspect of the bundle was confirmed by chart audit.

Interruption of Sedation and Readiness for Extubation. Nurses worked collaboratively with respiratory therapists to implement daily interruption of sedation and assessment of readiness for extubation. Each patient's sedation was interrupted and readiness for extubation was assessed by both a nurse and a respiratory therapist. Documentation of this aspect of the bundle was done on a respiratory therapy flow sheet. Compliance was monitored via chart audit. Nurses and respiratory therapists received real-time feedback on this aspect of the bundle via the feedback tool.

Subglottic Suctioning. Conventional endotracheal tubes were placed with Hi-Lo Evac endotracheal tubes (Covidien). These tubes have an extra port above the inflated cuff that was connected to

Table Ventilator-associated pneumonia bundle

Institute of Healthcare Improvement bundle	Expanded bundle	Rationale for modification or addition
Daily interruption of sedation and assessment of readiness for extubation	Daily interruption of sedation and assessment of readiness for extubation	No change
Peptic ulcer disease prophylaxis	Peptic ulcer disease prophylaxis	No change
Deep-vein thrombosis prophylaxis	Deep-vein thrombosis prophylaxis	No change
Daily oral care with chlorhexidine	Oral care with chlorhexidine plus additional mouth care	Bundle modified because increasing mouth care to every 2 hours can decrease development of ventilator-associated pneumonia[12,17,24]
Elevation of the head of the bed	Elevation of the head of the bed plus alarms	Alarms added to alert staff if the head of the bed is elevated less than 30°[16,17]
	Handwashing protocol Health care professionals required to (1) wash their hands with alcohol-based hand rub and don a pair of gloves before patient contact, and (2) after each patient contact, remove the gloves and wash their hands again with an alcohol-based hand cleanser	Added because hand washing can reduce the frequency of hospital-acquired infections[26-30]
	Subglottic suctioning Conventional endotracheal tubes replaced with Hi-Lo Evac endotracheal tubes, which have an extra port above the inflated cuff that was connected to low continuous suctioning	Added because low continuous subglottic suctioning promotes drainage or oral secretions from above the cuff, decreasing the chance that secretions might seep into the lungs[31]
	Feedback tool consisting of a database for tracking and determining trends in compliance with the expanded bundle, developed by the quality department, nursing staff, and information technology department Each component assigned to a specific group of health care practitioners Documentation on the medical record indicating bundle compliance monitored daily and information on compliance or needed improvements e-mailed to the patient's nurse, physician, and respiratory therapist and copies sent to nurse managers When all requirements met, congratulatory notes for staff members For consistent trends of noncompliance, meetings between nurse managers and staff to develop strategies for improvement	Added because using computerized audit tools to calculate bundle compliance can decrease rates of ventilator-associated pneumonia[32,33]

low continuous suction. Continuous low suction promoted drainage of oral secretion from above the cuff, therefore decreasing the chance that secretions would seep into the lungs. The cost of the tubes used for subglottic suctioning was $12.42.

Feedback Tool. Even after an extensive educational program was put into place, compliance with the VAP bundle continued to be less than expected. The interdisciplinary team decided that the process for implementing the VAP bundle should be evaluated and that a mechanism was needed for holding nurses accountable for the practices included in the bundle. When Cocanour et al[32] used a computerized audit tool to calculate weekly bundle compliance, the VAP rate decreased to less than the National Nosocomial Infections Surveillance System 25th percentile and was sustained for the remainder of their study. Zaydfudim et al[33] made compliance a key factor in their VAP

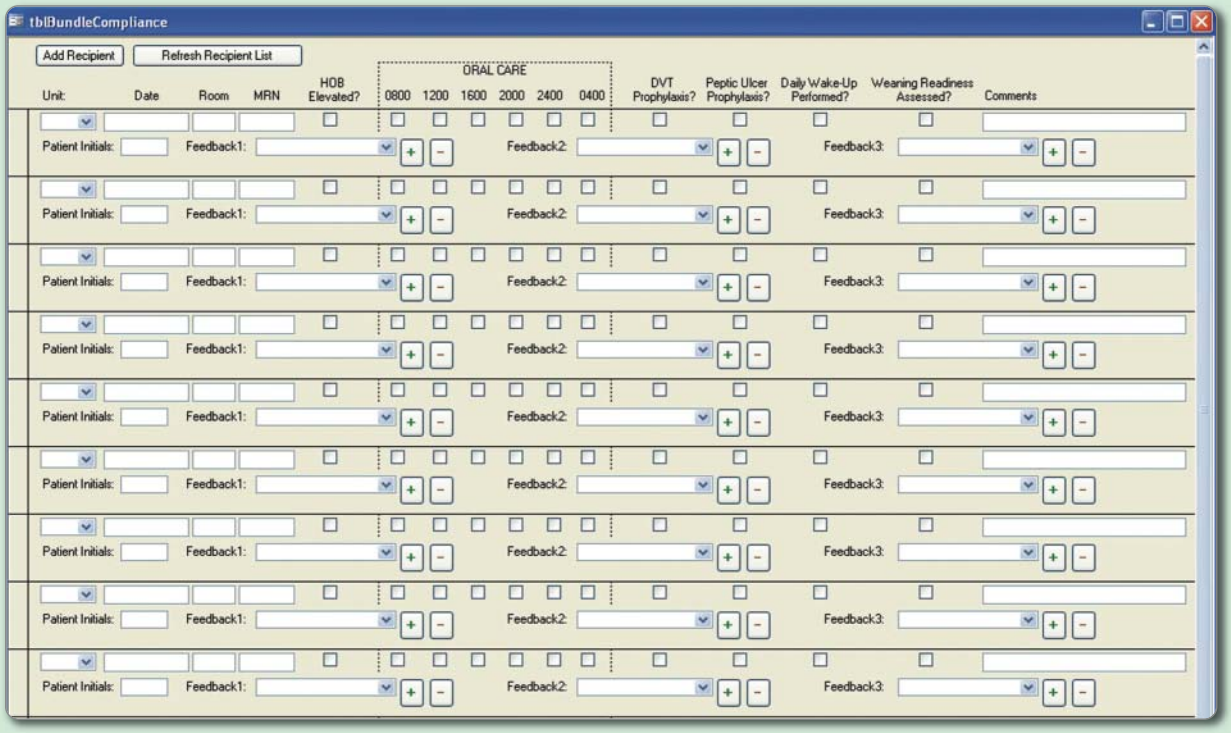

Figure 1 Compliance data and feedback tool.

bundle program. When implementation of a bundle program with intermittent compliance monitoring did not reduce the incidence of VAP at Lankenau, a real-time VAP bundle compliance dashboard was installed on every ICU computer monitor (Figure 1). Real-time compliance feedback resulted in an increase in total bundle compliance from approximately 20% to 90% during a year and the overall VAP rates improved.

Results

We began preliminary data collection in October 2008. In January 2009, daily audits were started, and use of the feedback tool was initiated. Compliance with each aspect of the VAP bundle was monitored and reported monthly. The findings from January 1, 2009, to December 31, 2009, are presented here. During 2009, the total number of ventilator days was 4709, a decrease from the 4964 ventilator days for January 1, 2008, to December 31, 2008.

The first month after education of staff members, compliance was 100% for PUD prophylaxis, DVT prophylaxis, daily interruption of sedation and assessment of readiness for extubation, and HOB elevation. Generally, the compliance rate remained greater than 98%, and for several months, compliance was 100% for PUD prophylaxis, DVT prophylaxis, daily interruption of sedation and assessment of readiness for extubation, and HOB elevation. The protocols for oral care and readiness for extubation were much more challenging. Compliance with the oral-care protocol never reached 100%. In October 2008, compliance was 76%, and the rate stayed within a range of 91.4% to 96.8% from February 2009 through December 2009. Readiness for extubation was 100% for 5 months but decreased near the end of the project to 92.4%.

From January 2008 through December 2008, a total of 47 cases of VAP occurred, with 4964 ventilator days, yielding 9.47 cases per 1000 ventilator days. From January 2009 through December 2009, a total of 9 cases of VAP occurred, with 4709 ventilator days, yielding a VAP rate of 1.9 cases per 1000 ventilator days (Figure 2).

Use of the VAP bundle resulted in a marked cost savings for Lankenau Hospital and improvement in patient outcomes. If the hospital's costs for each case of VAP is $40 000 (the calculated costs per episode of VAP according to the data from the IHI 5 Million Lives Campaign), the project resulted in an estimated savings of $1.5 million.

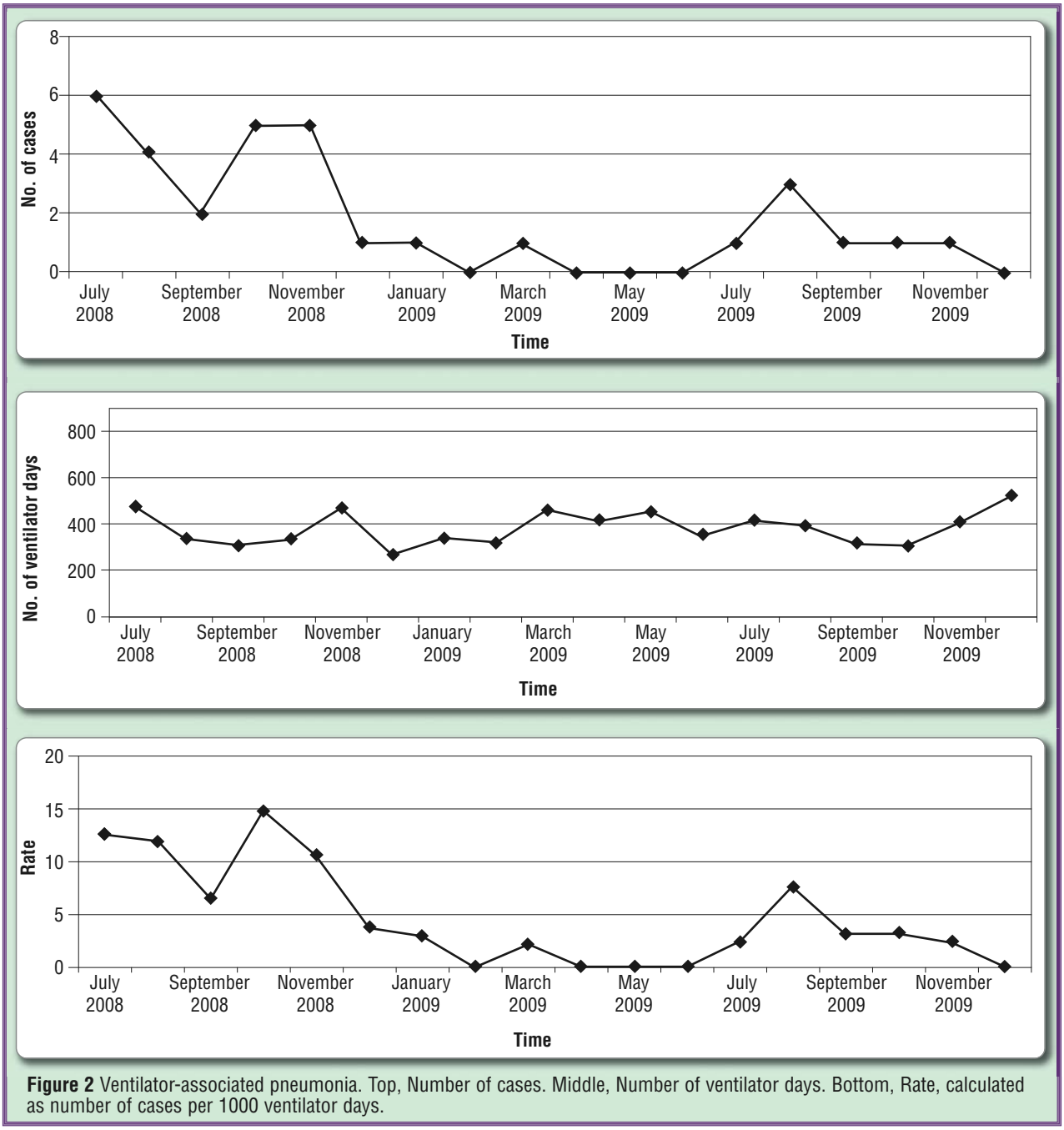

Figure 2 Ventilator-associated pneumonia. Top, Number of cases. Middle, Number of ventilator days. Bottom, Rate, calculated as number of cases per 1000 ventilator days.

Discussion

The success of our program was attributable to several factors. First, we think that the implementation of bundled practices contributed to a reduction of the VAP rates. Over the years, without consistent success, an enormous effort has been spent overcoming barriers to implementation of guidelines to reduce VAP rates. One of the earliest programs was described in the 1990s. The VAP-bundle concept has grown from the IHI 100 000 Lives Campaign in 2002, which had 4 elements—HOB elevation, daily sedation vacation, PUD prophylaxis, and DVT prophylaxis—to include a fifth element: oral care with chlorhexidine. Clinical evidence[13] indicates that implementation of each element of the VAP bundle reduces the mortality and morbidity of patients receiving mechanical ventilation. In a 38-month study in a surgical ICU, Bird et al[34] compared VAP rates before and after initiation of the IHI bundle. Before use of the bundle, the VAP rate was 10.2 cases per 1000 ventilator days. During

the study period, the rate decreased to 3.4 cases per 1000 ventilator days. Bird et al concluded that use of a VAP bundle was an effective method for reducing VAP rates when compliance with the protocols was maintained.

Second, having an interdisciplinary team involved in the project influenced the VAP rates. Nurses, physicians, respiratory therapists, quality department personnel, and information technology specialists played key roles in the success of the program. Use of an interdisciplinary team was further exemplified in a study by Johnson et al[35] in which they examined the effect of multidisciplinary rounds on VAP rates in trauma patients. They found that the number of VAP cases per 1000 ventilator days decreased from 34.4 to 23.4 between groups that did and did not have multidisciplinary rounds ($P = .04$).

Implementation of the mouth-care protocol could not have been successful without the assistance of the respiratory therapy department. The willingness of respiratory therapists to alternate responsibility for the mouth-care protocol enabled nurses to preserve resources to manage other aspects of patient care as well as the VAP bundle.

Third, we think that having an independent auditor assess compliance with the VAP bundle was one of the most important factors in the success of the project. Nursing staff were committed to making a difference in patients' outcomes. Nurses stated in staff meetings that they would not be satisfied with mediocre changes in the VAP rates. They established a zero-defect quality goal and welcomed the independent auditor. Staff viewed the independent auditors as nonbiased, and the nurses thought that having an auditor saved nursing time. Nurses indicated that they wanted to stay at the bedside and not be taken away from patient care to do data collection.

Finally, we think that the real-time feedback on staff compliance with the VAP protocol had the most important effect on VAP rates. Feedback sessions were used to give staff members positive feedback for their efforts and to increase staff accountability for implementation of best practices. Our use of real-time feedback was validated in another study[33] in which use of bundled practices along with electronic monitoring resulted in a significant reduction of VAP rates.

Implications for Nursing Practice

Our results confirm that nurses can improve patients' outcomes through the use of evidence-based practices. The evidence supporting VAP bundled practices is clear. We showed that strict adherence to a VAP bundle improved morbidity, mortality, and health care costs.

Accountability for daily patient care is a key component to improving patients' outcomes. Through the use of a feedback system, using daily monitoring and trend reports, nurses can remain abreast of their compliance with care protocols and develop strategies to improve patients' care.

Nurses need to be consistently apprised of patient safety issues and provided with the support to deliver high-quality care. The feedback tool, use of the electronic medical record, and other strategies can be developed to address staff performance and other quality issues.

Interdisciplinary collaboration is imperative when addressing issues such as VAP. Each member of the health care team must be willing to share in the responsibility for developing strategies to address problems in patient care and take an active role in implementing the plan.

Our VAP project was extremely successful. Nurses and other health care professionals can use our project as a template for addressing other quality projects, such as pressure ulcers, falls, and bloodstream infections. We plan to continue surveillance of compliance with protocols for managing other nurse-sensitive indicators. We would like to build an infrastructure to collect data so that nurses can monitor compliance with other protocols critical for improved patients' outcomes.

Conclusions

Health care costs surpassed $2.3 trillion in 2008 and account for 16% of the gross domestic product in the United States.[36] Intensive care costs account for 30% of hospital spending.[37] Because 76% of patients in ICUs require ventilatory support and the use of mechanical ventilation makes patients susceptible to VAP, interventions based on credible evidence are warranted. Strict adherence to VAP bundled practices, enhancing accountability for

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To learn more about ventilator-associated pneumonia, read "Patient to Nurse Ratio and Risk of Ventilator-Associated Pneumonia in Critically Ill Patients" by Blot et al in the *American Journal of Critical Care,* 2011; 20: e1-e9. Available at **www.ajcconline.org**.

initiating protocols by using a feedback system, and interdisciplinary collaboration most likely will improve patients' outcomes and produce marked costs savings for hospitals. CCN

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CNE Test

Test ID C1242: Using Evidence-Based Practice to Prevent Ventilator-Associated Pneumonia

Learning objectives: 1. List the components of the 2010 Institute for Healthcare Improvement ventilator bundles 2. Discuss the financial implications of patients developing ventilator-associated pneumonia 3. Identify strategies to help implement ventilator bundles successfully in a hospital

1. Which of the following is true concerning the cost of ventilator-associated pneumonia (VAP)?
a. VAP represents 75% of all intensive care unit infections.
b. The mortality rate for patients acquiring VAP is 32%.
c. VAP can increase length of stay by 4 to 19 days.
d. VAP does not significantly increase the cost of care.

2. What are the implications of the Center for Medicare and Medicaid Services declaring VAP to be a reasonably preventable occurrence?
a. The potential for VAP may increase in hospitals.
b. Hospitals will not be reimbursed for the cost of care associated with VAP.
c. Hospitals with a high VAP rate will lose accreditation.
d. Hospitals will be rewarded for discovering VAP early.

3. Which of the following patient assessment characteristics is most likely associated with VAP?
a. Infiltrates on the chest radiograph clearing after 24 hours of mechanical ventilation
b. Elevated white blood cell count and fever before intubation
c. Progressive infiltrates and fever on day 3 of mechanical ventilation
d. Purulent secretions present during intubation

4. Which of the following patient findings increases the risk of microorganisms entering the lower respiratory tract?
a. An increased gag reflex
b. Increased pooling of secretions in the oropharynx
c. Increased mucocillary clearance of secretions
d. Increased cough

5. Which of the following patients is the least likely to develop VAP?
a. A patient with elevation of the head of the bed (HOB) 20°, receiving H_2 blockers and oral care with toothettes every 4 hours
b. A patient with elevation of HOB 30°, receiving H_2 blockers and oral care with chlorhexidine daily, and treated with a change in the mode of ventilation daily
c. A patient with elevation of HOB 30°, receiving H_2 blockers, oral care with chlorhexidine daily, and continuous Propofol infusions
d. A patient with elevation of HOB 30°, receiving H_2 blockers and oral care with chlorhexidine daily, and treated with daily sedation awakenings with spontaneous breathing trials

6. Which of the following is true concerning the Institute for Healthcare Improvement ventilator bundles?
a. It is not necessary to implement all the components at once.
b. HOB elevation should remain less than 30° at all times.
c. The results of the 100 000 Lives Campaign showed a decrease in VAP rates following implementation of the bundles.
d. The 2005 bundles were unchanged in 2010.

7. What is a spontaneous awakening trial?
a. Turning off the continuous intravenous sedation and assessing the patient's respiratory status.
b. Turning off the rate on the ventilator and seeing if the patient awakens.
c. Changing the delivery method of sedation from intravenous to by mouth.
d. Increasing the sedation at night to allow the patient to sleep.

8. Which of the following were revealed in the meta-analysis on application of oral antiseptics, antibiotics, and placebo?
a. Applying oral antibiotics significantly decreased VAP incidence.
b. Applying oral antiseptics significantly decreased VAP incidence.
c. Standard oral care only significantly decreased VAP incidence.
d. Applying oral antibiotics and antiseptics did not affect VAP incidence.

9. What is the SMART approach to reducing hospital-acquired infections?
a. Specific Measurable Achievable Redundant Time-bound approaches
b. Several Meaningful Achievable Relevant Time-bound approaches
c. Specific Measurable Actively Relevant Time-bound approaches
d. Specific Measurable Achievable Relevant Time-bound approaches

10. Which of the following is true according to the hand hygiene research cited in the article?
a. There was a 50% increase in compliance rates of hand hygiene with the bundle implementation.
b. Use of alcohol rub was associated with higher hand contamination.
c. Hand washing is not necessary if gloves are changed frequently.
d. Ring wearing was associated with a 10-fold increase in *Staphylococcus aureus* and *Candida* infections.

11. Which of the following results was achieved by the Lankenau Hospital bundle implementation?
a. Compliance with the oral care protocol was 100%.
b. VAP occurrences decreased from 47 (2008) to 9 (2009).
c. Peptic ulcer disease and deep-vein thrombosis prophylaxis compliance rates were 92%.
d. Ventilator days increased from 4709 (2008) to 4964 (2009).

12. According to a study cited in the article, how did multidisciplinary team rounds affect VAP rates in trauma patients?
a. VAP rates were unaffected by multidisciplinary team rounds.
b. VAP rates increased when teams conducted daily multidisciplinary rounds.
c. VAP rates decreased when teams conducted daily multidisciplinary rounds.

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
❑a	❑a	❑a	❑a	❑a	❑a	❑a	❑a	❑a	❑a	❑a	❑a
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