Performance Improvement

Implementing a Ventilator Bundle in a Community Hospital

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Ventilator-associated pneumonia (VAP) is the most common hospital-acquired infection among ventilator patients and has been associated with extended hospital lengths of stay (LOS) and higher rates of mortality for patients.[1] Average VAP rates in hospitals across the United States vary from 2.9 VAPs per 1,000 ventilator days in pediatric ICUs to 15.2 VAPs per 1,000 ventilator days in trauma ICUs.[2] Research has shown mortality rates ranging from 24% to 50%, depending on individual co-morbidities and pathogens involved.[3] Although some studies have not found VAP to be an independent contributor to intensive care unit (ICU) mortality,[3] hospital-acquired pneumonia increases complexity of care, ICU LOS by 6.1 days, and hospital LOS by 10.5 days.[4] Each VAP is estimated to add $40,000 to the cost of a patient's care.

Reductions of ventilator-associated pneumonia (VAP) associated with use of a bundle concept have recently been reported.[5] As a known complication with significant morbidity and mortality, VAP has also become one of the primary interventions for the 5 Million Lives Campaign, formerly known as the 100,000 Lives Campaign, initiated by the Institute for Healthcare Improvement (IHI).[6]

Mercy & Unity Hospitals of Minnesota implemented the IHI ventilator bundle concept as part of its participation in an IHI Breakthrough Series collaborative on improving care in the ICU, which was conducted from June 2003 through May 2004. This articles reports on the work that Mercy & Unity Hospitals conducted within the collaborative.

Article-at-a-Glance

Background: Mercy & Unity Hospitals of Minnesota implemented the ventilator bundle concept as part of an Institute for Healthcare Improvement (IHI) collaborative on improving care in the intensive care unit (ICU).

Methods: The two hospitals, which function as a single hospital, have a total of 450 beds, and each has a 20-bed ICU. The IHI bundle was composed of (1) head-of-bed elevation, (2) a daily "sedation vacation" along with a readiness-to-wean assessment, (3) peptic ulcer disease prophylaxis, and (4) deep vein thrombosis prophylaxis. Additional interventions likely complementary to the ventilator bundle were a hand hygiene campaign and an oral care protocol.

Results: Overall compliance with the four bundle elements reached 100% by January 2004. At the end of the collaborative, Mercy's VAP rate decreased from 6.1 to 2.70 per 1,000 ventilator days, and Unity's VAP rate decreased from 2.66 to 0 per 1,000 ventilator days.

Discussion: The all-or-none nature of the bundle may have helped multidisciplinary staff members perceive the project as a systemic change versus a one-time intervention. Staff members needed to implement both structural changes, such as preprinted order sets for ventilator management and sedation, and cultural changes, such as increased collaboration with respiratory therapy.

Conclusion: The decrease in VAP provides a promising example of the potential of intervention techniques and bundle implementation in a community hospital.

Methods

Setting

Mercy & Unity Hospitals, located nine miles apart in the northern suburbs of Minneapolis, are part of Allina Hospitals & Clinics, a not-for-profit network of hospitals, clinics, and other health care services, that provide care throughout Minnesota and western Wisconsin. The hospitals function as a single hospital with two campuses and have a combined total of 450 beds. Intensive care beds include a 20-bed unit at Mercy, which combines a medical-surgical unit with cardiovascular surgery, and a 20-bed combined medical-surgical unit at Unity.

Ventilator Bundle

One of the key change concepts offered in the IHI collaborative was implementation of a ventilator bundle. The IHI bundle was composed of the following four elements[5]:

1. Head-of-bed (HOB) elevation
2. Implementation of a daily "sedation vacation" along with a readiness-to-wean assessment
3. Peptic ulcer disease prophylaxis
4. Deep vein thrombosis prophylaxis

Additional interventions that were likely complementary to the ventilator bundle were a hand hygiene campaign and an oral care protocol (which included oral care every two hours with swabs and a peroxide-based solution, teeth-brushing every 12 hours and a subglottic secretion removal every 6 hours.)

Several written communications were important in reminding and motivating ICU staff members about bundle implementation. Data on VAP rates were posted near nurse break rooms with initials of the patient included on the posters to help maintain motivation and focus on the fact that each complication happens to a real patient. Fact sheets and in-services were provided to bedside providers about the ventilator bundle. Compliance with the bundle was tracked in visible ways, including a goals sheet used during daily, multidisciplinary rounds.

The implementation of the ventilator bundle elements is now described.

1. HOB Elevation

As a compromise between literature that recommends an angle of 45 degrees[7] and staff members' concern about possible pressure ulcers and patients sliding down in bed, a 30-degree angle was selected as the minimum HOB elevation. The unit clinical nurse specialist performed daily written assessments to determine whether the practice was being followed. If not, the assessment became an opportune time to teach about the benefits of HOB elevation and to discuss options for patients who could not tolerate a 30-degree elevation but may be able to tolerate a lesser elevation.

In the beginning, the clinical nurse specialist and two nurse champions performed multiple informal assessments in addition to the daily written assessments. Their constant presence was key to spreading the practice throughout the unit. Other tools were helpful as well. For example, reminder signs were placed in rooms where 30-degree HOB elevation was applicable. Nurses and respiratory therapists were jointly responsible to ensure a minimum HOB elevation in all patients without contraindications. Monthly compliance audits were completed by the unit clinical nurse specialists, and the data were fed back to clinical staff.

2. Daily Sedation Vacation and Readiness-to-Wean Assessment

The Mercy & Unity team implemented the sedation vacation through the use of rapid-cycle change methodology whereby several physicians and registered nurses (RNs) were selected to develop and test a revised order set for ICU sedation. Reduction in sedation occurred on a daily basis unless medically contraindicated. The interventions were reinforced by daily multidisciplinary rounds.

Each shift, a patient care nurse (RN) and a respiratory therapist jointly evaluated each ventilator patient's readiness-to-wean through the use of a well-established weaning parameter, the rapid shallow breathing index[8] and by reviewing medications, hemodynamic stability, and alertness. If the patient met the criteria for readiness to wean (Table 1, page 221), then a weaning trial could be implemented. In some instances, the physician chooses to play a more active role in the weaning process and is contacted for input before a weaning trial is undertaken.

3. Peptic Ulcer Disease Prophylaxis

Famotidine (Pepcid) 20 milligrams twice per day was used as the standard prophylaxis unless modified because of concurrent medications, renal status, and mental status.

Table 1. Readiness to Wean Criteria*

First Assessment Upon Admission to ICU

For neurosurgical patients do not assess weaning readiness or attempt weaning trial until direct physician order.

- Alertness to voice
- Hemodynamic stability: BP controlled, rhythm stable (may be on continuous IV medications for control) Exclude: Dopamine/Dobutamine ≥ 6 mcg/kg/min, Diltiazem ≥ 10 mg/hr
- Temperature < 101 degrees F
- Oxygen saturation ≥ 90% on < 60 FIO_2 and < 5 cm PEEP

Failure to Wean Criteria

- RR < 6 or RSB index > 100
- HR increase of > 20% baseline, ventricular ectopy or SVT
- Change in mental status
- Worsening clinical status
- If wean failure X 2 or patient on ventilator > 72 hours, obtain a pulmonary consult.
- HR > 130 bpm
- 0_2 saturation < 90%
- Increased agitation
- Worsening of secretions

*ICU, intensive care unit; BP, blood pressure; IV, intravenous; FIO_2, forced inspiratory oxygen; PEEP, positive-end expiratory pressure; RR, respiratory rate; RSB, rapid shallow breathing; HR, heart rate; SVT, sinoventricular tachycardia; BPM, beats per minute.

Stress ulcer prophylaxis was discussed daily in multidisciplinary rounds as a redundancy to assure compliance with this element of the bundle.

4. Deep Vein Thrombosis Prophylaxis

Several treatment options were developed. Unless contraindicated, elastic compression stockings with pneumatic compression devices were automatically applied to each patient.

Chart Reviews

Retrospective chart reviews for January 2003 through June 2003 were completed by clinical nurse specialists, who used the revised Centers for Disease Control & Prevention (CDC)–National Nosocomial Infections Surveillance System (NNIS) definitions for VAP were used.[9] VAP rates were calculated by using the number of ventilator hours divided by 24, with a denominator of 1,000 ventilator days.

Clinical nurse specialists coordinated completion of the surveillance check list for every ventilated patient. Questions were discussed with the infection control practitioner, and all "possible pneumonia" charts were reviewed by the infection control practitioner for the final determination.

ICU patients' charts were reviewed for the duration of their ICU LOS for the presence of symptoms developing 48 hours after intubation that were not incubating or present on ICU admission. These patients' chest x-rays and other CDC criteria were reviewed until 48 hours after the ventilator was discontinued or the patient was transferred out of the ICU.

Prospective chart reviews since July 2003 have been completed using slightly different methodology at the two campuses. At the Mercy campus, they are completed by the respiratory care advisory team in a group setting with the infection control practitioner. At the Unity campus, the clinical nurse specialist prospectively completes the chart reviews and discusses possible cases with the ICU medical director and the infection control practitioner. At both campuses, the infection control practitioner reviews all "possible pneumonia" charts for the final determination.

On both campuses, the infection control practitioner conducts inter-rater reliability testing on a random basis for all patients with abnormal chest x-ray presentation. Each surveillance checklist is completed for each ventilated patient who has been on the ventilator for 24 hours. To explore whether any pneumonia cases were missed, the infection control practitioner reviews the *International Classification of Diseases,* 9th revision (ICD-9) code for pneumonia, electronic reports of temperature, elevated white blood counts, and mentation changes in patients older than 70 years of age.

Beginning in July 2004, at the end of the collaborative, ventilator days were collected by the ICU staff at midnight to include each patient that was on a ventilator as a ventilator day. The number of ventilator infections was divided by the number of ventilator days and multiplied by a constant value, 1,000, to report rates as the number of ventilator pneumonias per 1,000 ventilator days.

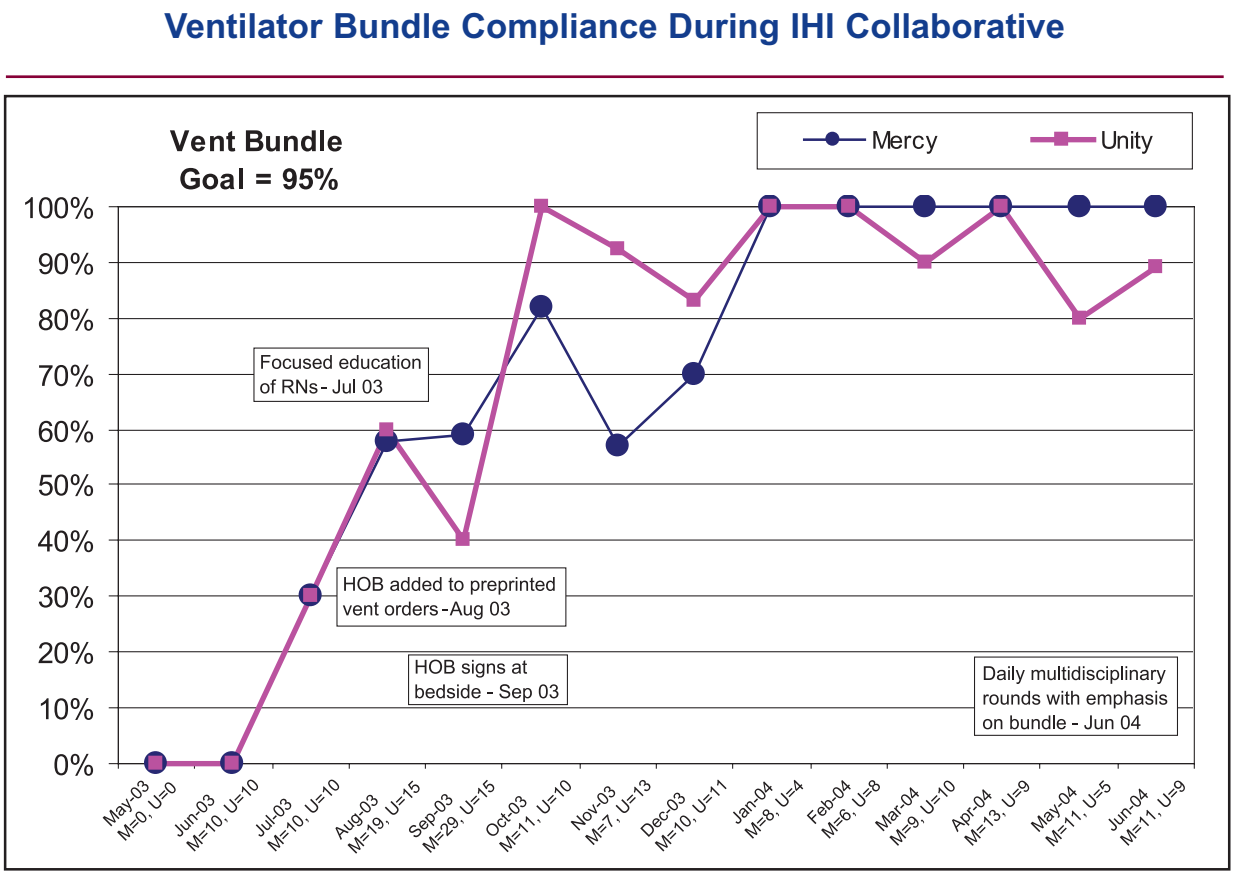

Figure 1. *Compliance of 100% was reached by January 2004 after focused RN education about the bundle, addition of head-of-bed (HOB) orders to preprinted ventilator order sets, and placement of the HOB elevation reminder signs in rooms of patients when it was not contraindicated. The number of ventilator patients audited each month is shown for Mercy (M) & Unity (U) Hospitals.*

Results

Data collected for the VAP bundle included one process measure, which identified overall compliance to the four bundle elements. Outcome measures included the total number of ventilator days, the frequency of VAP, ICU average LOS, and ICU mortality. The initial process goal was to implement all bundle components within 24 hours of admission in 95% of patients. Compliance of 100% was reached by January 2004 after focused R.N. education about the bundle, addition of HOB orders to preprinted ventilator order sets, and placement of the HOB elevation reminder signs in rooms of patients where HOB elevation was not contraindicated (Figure 1, above).

The baseline VAP rate from January 2003 to June 2003 for the Mercy campus was 6.01 per 1,000 ventilator days and 2.66 per 1,000 ventilator days at the Unity campus. At the end of the collaborative (June 2004), Mercy's VAP rate decreased by 55% to 2.70 per 1,000 ventilator days, and Unity's VAP rate decreased to 0 per 1,000 ventilator days (Figure 2, page 223). The VAP rate at Mercy continued to decrease—to 2.20 per 1,000 ventilator days. Unity experienced one VAP case, which brought its rate to 1.47 per 1,000 ventilator days. In 2006, Mercy's VAP rate was 0 per 1,000 ventilator days and Unity's VAP rate was 1.69 per 1,000 ventilator days.

Both campuses' rates are below the published CDC pool mean rates for non-teaching medical-surgical ICUs of 5.1 per 1,000 ventilator days.[1] In addition, there has been a statistically significant reduction (p = .02) in average LOS for ventilator patients at the Unity campus between 2003 and

2004 (Table 2, page 224). At Mercy, there was not a statistical difference in LOS for ventilator patients, although the LOS was already low (9.0 days).

Discussion

Bundles, as defined by IHI, are a cohesive unit of evidence-based interventions that should be implemented as a set[6] as a strategy to help reduce inpatient mortality. Bundle theory posits that a set of practices implemented all at once improves reliability because it demands a high level of teamwork and fundamental changes in how work is performed.[5] Experiences with the VAP bundle have shown that use of the bundle is correlated with significant decreases in VAP rates, despite the fact that two of the four bundle elements (deep vein thrombosis prophylaxis and stress ulcer prevention) have not been correlated specifically with VAP reduction.[5]

Overall Ventilator-Associated Pneumonia (VAP) Rates (per 1,000 Days) at Mercy & Unity Hospitals, January 2003–September 2006

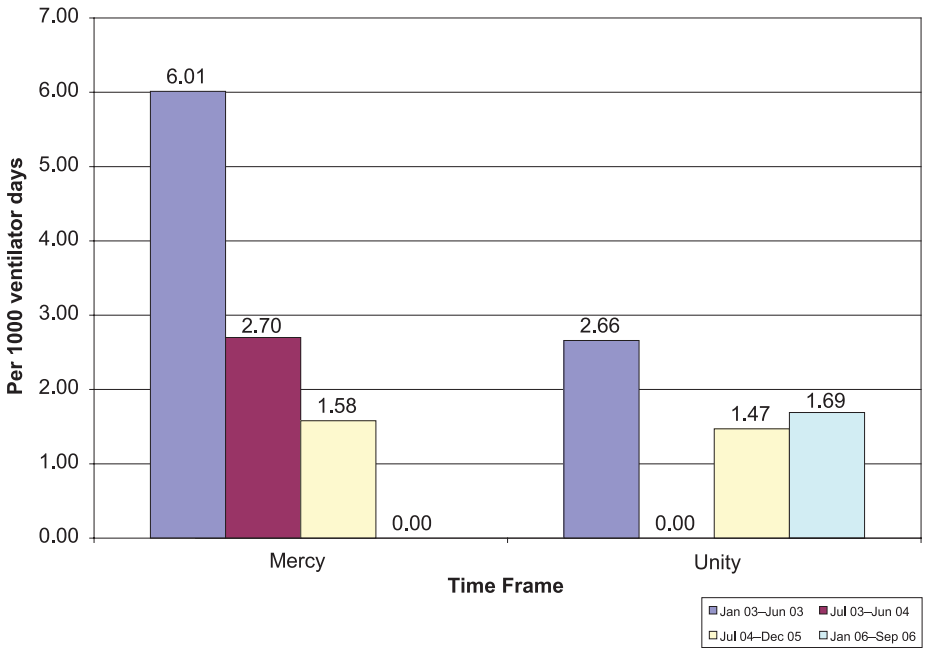

Figure 2. *At the end of the collaborative (June 2004), Mercy's VAP rate had decreased by 55% to 2.70 per 1,000 ventilator days, and Unity's VAP rate had decreased by 100% to 0 per 1,000 ventilator days.*

We believe the all-or-none nature of the bundle helped multidisciplinary staff members perceive the project as a systemic change versus a one-time intervention. To meet the all-or-none compliance goal, staff members needed to implement both structural changes, such as preprinted order sets for ventilator management and sedation, and cultural changes, such as discussion of VAP at multidisciplinary weekday rounds and increased collaboration with respiratory therapy. The immensity of the change required staff members to approach the project as a team, keep a constant focus on the topic, and develop new relationships and processes.

One particularly challenging culture change was implementation of HOB elevation. The challenge was to keep staff members focused on HOB elevation throughout the day as patients were moved or manipulated in the process of care. In the first few months, the clinical nurse specialist and two nurse champions on the unit each performed informal assessments multiple times a day, in addition to one daily written assessment of HOB elevation. Their presence served as a reminder to nursing staff and also generated productive discussions about elevations of less than 30 degrees that might be tolerated by patients with contraindications to a full 30 degrees. The "constant drumbeat" about HOB elevation in the beginning of the campaign solidified the change in the patient care environment.

Although the IHI collaborative promoted implementation of all bundle elements unless they were medically contraindicated, it recommended that hospitals implement the bundle according to each organization's unique needs.[6] We believe that such flexibility hastened implementation by allowing adaptation of the initiative to preexisting structures in our individual environments. For

example, prospective chart reviews for "possible pneumonia" cases were completed with slightly different methodology on our two campuses. On the Unity campus, such cases were flagged by a clinical nurse specialist, then discussed with the ICU medical director and infection control practitioner. On the Mercy campus, staff members folded chart review work into the pre-existing respiratory care advisory team.

Although the all-or-none bundle sparked systemic and cultural changes, measurable outcomes appeared to be a more significant motivating factor for continued focus on VAP rates once the collaborative was over. When front-line staff members realized during the collaborative that VAP rates were falling, they began questioning how they could build on their successes after the collaborative. Analysis of VAP events and efforts to encourage bundle compliance remained in place. The campuses' joint multidisciplinary critical care quality improvement committee took on the task of pursuing other opportunities to affect VAP rates. Because the two campuses function as one hospital, with mostly the same policies, procedures, and equipment, the committee determined that further analyses could help target small differences in practices that could affect VAP rates. Analyses on each campus revealed differences in endotracheal saline instillation protocols and identified several better practices, which were subsequently implemented systemwide:

- Limiting of saline instillation because of a lack of supporting evidence[10]
- Use of a inline-catheter to maintain the closed suction system
- Documentation of in-line suction catheter changes every 72 hours per the manufacturer's recommendations
- Use of a new device for removal of condensation in ventilation tubing to prevent accidental patient lavage
- Locking of suction port when not in use to prevent accidental patient lavage

Education was undertaken on these practices, as well as on the following:

- The importance of not leaving saline bullets attached to suction catheters and also to announce a transition to the use of 5-ml sterile saline bullets
- Proper endotracheal and subglottic suctioning techniques to help reduce migration of oral secretions past the endotracheal tube

Table 2. Length of Stay (LOS) for Intensive Care Unit Ventilator Patients, Unity Campus, 2003–2004*

Year	Total Number of Patients	LOS Hours	ALOS	S.D.
2003	205	65,342.0	13.3	12.34
2004	224	58,165.0	10.8	10.50

* S.D., standard deviation; $p = .02$.

- Use of the correct port for saline lavage.

An initial audit performed in June 2004 at the conclusion of the collaborative revealed a compliance rate for all eight practices of 74%. In August 2004, after education (which included one-on-one sessions, staff in-services at shift change, and a display), a repeat audit showed a compliance rate of 93%. Currently, random audits are completed to monitor compliance. Other activities undertaken during the same postcollaborative time period included review and implementation of recommendations from evidence-based guidelines. For example, the team standardized time intervals for changing heat-moisture exchangers and closed suction catheters. They also performed a gap analysis using the 2003 CDC Guidelines for Preventing Health-Care Associated Pneumonia (published in March 2004[11]). These additional interventions relied on the platform of multidisciplinary teamwork and focus established during the IHI collaborative.

Some limitations of the study should be noted. Statistical significance in the VAP rate decrease was not established because of low rates at project commencement. A full accounting of patient status before and after bundle interventions would involve a detailed analysis of the patient population (including reasons for mechanical ventilation, ages, proportion of medical versus surgical patients) and a multivariate analysis to demonstrate the effect of the bundle on VAP rates; such an analysis was not undertaken. In addition, although steps were taken to avoid bias in the retrospective chart reviews, those reviews are inherently subject to human bias. At Mercy & Unity, several non-bundle initiatives undertaken before, during, and after bundle implementation were not analyzed for their effect on VAP rates, including the hand hygiene campaign, refinement and relaunching of oral care practices,

and the initiatives undertaken, as noted, by the critical care quality improvement committee.

Conclusion

Although further study is needed on the ventilator bundle and the additional interventions conducted at Mercy and Unity, the reported decrease in VAP provides a promising example of the potential of VAP intervention techniques and bundle implementation in a community hospital setting.

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