Decreasing ventilator-associated pneumonia in adult intensive care units using the Institute for Healthcare Improvement bundle

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Background: Ventilator-associated pneumonia (VAP) increases in-hospital mortality of ventilated patients to 46%, compared with 32% for ventilated patients who do not develop VAP. In addition, VAP prolongs time spent on the ventilator, length of intensive care unit (ICU) stay, and length of hospital stay.

Methods: In this study, we implemented VAP bundle to decrease the rate of VAP infection. This is a pre- and postintervention trial beginning in 2006 to decrease the rate of VAP in adult ICUs after initiation of the Institute for Healthcare Improvement (IHI) VAP bundle compared with the VAP rate for the preceding 12 months. The study was conducted at a private general hospital in Saudi Arabia. The study included all adult patients who were on mechanical ventilation from 2006 to 2008. An interdisciplinary performance improvement team was formed. The team implemented an evidence-based VAP bundle adopted from the IHI.

Results: The implementation of the VAP prevention bundle resulted in the reduction of VAP rates from a mean of 9.3 cases per 1000 ventilator-days in fiscal year 2006 to 2.3 cases per 1000 ventilator-days in 2007 and to 2.2 in 2008 (P < .001). It is estimated that each VAP case increases the hospital length of stay attributable by 10 days and the mean hospital cost by $40,000. Thus, the potential decrease in hospital cost is $780,000 annually.

Conclusion: Implementing the IHI VAP bundle significantly resulted in the reduction of the VAP rate with potential great cost avoidance.

Key Words: Ventilator-associated pneumonia, health care-associated infection; VAP; IHI; Institute for Healthcare Improvement; bundle; quality improvement; device-related infections.

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Ventilator-associated pneumonia (VAP) is a serious health care-associated infection, resulting in high morbidity, high mortality, and high costs of treatment.1,2 The incidence of VAP ranges from 10% to 25%, with mortality of 10% to 40%.3 VAP also prolongs hospital stay and drives up hospital costs.3 In a prospective surveillance study of VAP in a pediatric intensive care unit (ICU) in Saudi Arabia, the mean VAP rate was 8.87/1000 ventilation-days with a ventilation utilization rate of 47%.4 The mean pediatric ICU stay was 34 days for VAP patients and 15 days for non-VAP patients.4 In another study, the incidence density was 16.8/1000 person-days of ventilation.5 The Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network hospitals report a mean VAP rate of 3.6 per 1000 ventilator-days in medical-surgical ICUs.6 In developing countries, the rates of VAP vary from 10 to 41.7 per 1000 ventilator-days.7

In December 2004, the Institute for Healthcare Improvement (IHI) started a campaign to save 100,000 lives by implementing bundles. The concept of the care “bundle” works to facilitate the application of best practices and evidence-based care. A bundle is “a structured way of improving the processes of care and patient outcomes that, when performed collectively and reliably, are proven to improve patient outcomes.”8 Therefore, we undertook this study in the beginning of 2007 to decrease the rate of VAP in adult ICUs after initiation of the IHI VAP bundle compared with the VAP rate for the preceding 12 months.
METHODS

This study was conducted in the 18-bed adult ICU including the medical, surgical, and coronary care units at Dhahran Health Center, a 350-bed hospital in Eastern Saudi Arabia. Dhahran Health Center has 5 ICUs (cardiac, medical, surgical, pediatric, and neonatal). The study was conducted at the adult ICUs.

Design

In this preinterventional and postinterventional study, we compared the rates of VAP, on a monthly basis, from January to December 2006, for a 1-year period before the initiation of the VAP bundles. This rate was compared with the VAP rates after intervention from January 2007 to December 2008 (a 2-year period).

Intervention

In addition to routine infection control protocols, the VAP bundle was adapted from the IHI bundle of care. The IHI bundle is composed of (1) head-of-bed elevation, (2) a daily “sedation vacation,” (3) a readiness-to-wean assessment, (4) peptic ulcer disease prophylaxis, and (5) deep vein thrombosis prophylaxis. A sedation vacation is implemented by stopping a continuous sedation infusion until a patient is able to follow commands or becomes fully awake. If continued sedation is required after the vacation period, clinicians administer a bolus sedation dose to the patient before restarting the sedative infusion at half of the previous rate. We included all adult patients in the adult ICUs undergoing mechanical ventilation.

Measures

Two sets of measures were monitored: process and outcome measures. The process measure reflected the rate of adherence to the ventilator bundle. The outcome measure included the device utilization ratio and the rate of VAP per 1000 ventilator-days. The device utilization ratio was calculated by dividing the ventilator-days by the total ICU patient-days. The definition of VAP was based on the CDC’s National Nosocomial Infections Surveillance System definitions. We also estimated the potential cost avoidance based on the average attributable cost estimates of a single case of VAP as $40,000. The estimation of additional hospital stay was based on the report that patients with VAP had a significantly longer duration of hospital length of stay of about 10 days.

Implementation process

Multiple steps were taken to implement the ventilator bundle and include staff education, development of an audit tool, data collection, and tracking of the measures. A team approach to drive and maintain the initiative was developed and included the following: infection control professional, critical care nursing, respiratory therapist, intensivists, and chairman of the infection control committee. A protocol was developed for sedation vacation and assessment to extubate.

Staff education was accomplished by multiple presentations on VAP, the importance of the VAP bundle, discussion on the VAP elements, and encouraging the intensivist to adopt a protocol for the sedation vacation. After the initial educational session, a working group worked on the development of the VAP bundle checklist. The compliance with the bundle elements was recorded on daily basis using a checklist during a multidisciplinary round. Feedback was provided on compliance with these processes to the ICU team (doctors, nurses, and respiratory therapists). If noncompliance with an element of the bundle was detected, the nurse intervened in this process at the time of the monitoring process. A quarterly report of the compliance rate and the VAP rates were communicated to each ICU staff and was shared with the quality improvement and the executive staff committees.

VAP definitions

Based on the infection control committee guidelines in our hospital, VAP surveillance was performed by a trained infection control professional using the US CDC definition. A single infection control professional, who has more than 20 years of experience in infection control, collected the data on the development of the VAP using a standardized CDC criteria-based checklist. The infection control professional and the
The ICU team were not blinded to the study because the study was done as a part of the quality improvement projects. The incidence of VAP was expressed as cases of VAP per 1000 ventilator-days.

RESULTS

Adherence with all the elements of the VAP bundle improved from 20% in the first 3 months to 82% in the final 3 months of the intervention. There were 29 VAP events (9.3 events/1000 ventilator-days) during the 12-month period from January 2006 through December 2006 compared with 10 VAP events (3 events/1000 ventilator-days) in 2007 and 9 VAP events (2.1 events/1000 ventilator-days) in 2008 (Fig 1). Thus, the annual average VAP rate in the postintervention period was 2.5/1000 ventilator-days. This improvement appears to be sustained over the study period (Fig 2). The steepest decrease in VAP rate was observed after the initial full implementation of the bundle and afterwards reached a plateau. As a measure of the acuity and invasiveness in the ICUs, the device utilization ratio was 0.55. Thus, the device utilization ratio did not change over the study period and was comparable between pre- and postintervention.

It is estimated that each VAP case increases the hospital length of stay attributable by 10 days and the mean hospital cost by $40,000. Thus, the potential reduction in hospital days was 115 days (290 vs 95 days, respectively) (Table 1). The attributed VAP costs were $380,000 after implementation of the VAP prevention bundle with a potential avoidable cost of $780,000 annually (Table 1).

DISCUSSION

In the current study, we adopted the IHI VAP bundle that resulted in a significant decrease in the VAP rate and maintained such a reduction over 24 months. In Saudi Arabia, 2 previous studies were conducted to decrease the VAP rate. In a prospective randomized study in a tertiary care ICU, authors compared the incidence of VAP using the heat and moisture exchanger versus the heated humidifying system. They found no significant difference in the incidence of VAP between the 2 systems in which VAP rates were 15.7 and 13.3 per 1000 ventilator-days, respectively. In the same ICU, Arabi et al showed significant reductions in the use of analgesics and sedatives after 3 months of implementing a multifaceted multidisciplinary
approach and teamwork. This was associated with a decrease in the VAP rate from 28 to 11 per 100 patients.\textsuperscript{13}

We observed an 80\% reduction in the rate of VAP; however, a lower reduction rate of 44.5\% reduction was observed by other investigators.\textsuperscript{14} The application of the VAP bundle in Minnesota resulted in reduction of the VAP rate from 6.1 to 2.70 per 1000 ventilator-days in one unit and from 2.66 to 0 per 1000 ventilator-days in another unit.\textsuperscript{15} In another study, the use of a collaborative approach resulted in a decrease of the VAP rate from 15.3 to 8.3 per 1000 ventilator-days.\textsuperscript{16}

In another study, the application of the VAP bundle resulted in a 41\% reduction in VAP rate.\textsuperscript{17} In a study from the United Kingdom, the VAP incidence fell significantly from 19.2 to 7.5 per 1000 ventilator-days.\textsuperscript{18} Similar to the finding in the current study, a near zero VAP rate was accomplished after the implementation of an expanded respiratory therapist-driven set of protocols for decision regarding extubation.\textsuperscript{19} In a recent review, the VAP bundle was found to be an effective method to reduce VAP rates in ICUs. The authors suggested that the VAP bundle should be modified and expanded to include oral care and hygiene; chlorhexidine in the posterior pharynx; and specialized, silver-coated endotracheal tubes (continuous aspiration of subglottic secretions).\textsuperscript{20} Daily and weekly auditing of compliance with any intervention seems to also improve the VAP rates. In one study, VAP rates significantly decrease with intervention, from a range of 22.3-32.7 to a range of 0-12.8 per 1000 ventilator-days.\textsuperscript{5}

During the planning and implementation process, a few obstacles arose. One of the obstacles was related to the perception that such changes of the VAP bundle may compromise patient care and presents a risk for adverse events. This finding was more evident for nursing staff as reported previously.\textsuperscript{21} However, physicians were more resistant to change related to the implementation of the sedation vacation. The overall nonadherence rate to VAP bundle in a previous study was 37.0\%.\textsuperscript{22} We gave the physician autonomy to develop the protocol for sedation vacation and the readiness to extubate and thus were able to implement the VAP bundle. In a previous report, a collaborative effort

between nursing staff and the critical care pharmacist was important to develop a protocol for these elements.\textsuperscript{23}

In conclusion, we adopted an aggressive VAP bundle resulting in a marked reduction of the VAP rate. The rate was kept in the lower range even after 2 years of implementation. Thus, such measures are effective and require staff training and a multidisciplinary program.\textsuperscript{24} A well-developed and supported program will enhance the success rate of such interventions, especially if coupled with data feedback.

### References


### Table 1. A comparison between pre- and postintervention parameters

<table>
<thead>
<tr>
<th>Period</th>
<th>No. of infections</th>
<th>VAP rates per 1000 ventilator-days</th>
<th>Total ventilator-days</th>
<th>Added LOS (10 days/VAP)</th>
<th>Costs in $ + (added)(avoided) $</th>
</tr>
</thead>
<tbody>
<tr>
<td>January-December 2006 (before VAP bundle application)</td>
<td>29</td>
<td>9.3</td>
<td>3126</td>
<td>290</td>
<td>($1,160,000)*</td>
</tr>
<tr>
<td>Average annual (January 2007-December 2008) (after VAP bundle application)</td>
<td>9.5</td>
<td>2.5</td>
<td>3740</td>
<td>95</td>
<td>+($380,000)−($780,000)*</td>
</tr>
</tbody>
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inf, infection; LOS, length of stay.

*Avoidable cost.


