The impact of a ventilator bundle on preventing ventilator-associated pneumonia: A multicenter study

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**Background:** For prevention of ventilator-associated pneumonia (VAP), a bundle approach was applied to patients receiving mechanical ventilation in intensive care units. The incidence of VAP and the preventive efficacy of the VAP bundle were investigated.

**Methods:** A quasi-experimental study was conducted in adult intensive care units of 6 university hospitals with similar VAP rates. We implemented the VAP bundle between March 2011 and June 2011, then compared the rate of VAP after implementation of the VAP bundle with the rate in the previous 8 months. Our ventilator bundle included head of bed elevation, peptic ulcer disease prophylaxis, deep venous thrombosis prophylaxis, and oral decontamination with chlorhexidine 0.12%. Continuous aspiration of subglottic secretions was an option.

**Results:** Implementation of the VAP bundle reduced the VAP rate from a mean of 4.08 cases per 1,000 ventilator-days to 1.16 cases per 1,000 ventilator-days. The incidence density ratio (rate) was 0.28 (95% confidence interval, 0.275-0.292).

**Conclusions:** Implementing the appropriate VAP bundle significantly decreased the incidence of VAP in patients with mechanical ventilation.

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Ventilator-associated pneumonia (VAP) is one of the most important health care–associated infections (HAIs), resulting in high morbidity and mortality and substantial associated costs. Prevention of VAP has been highlighted as a priority, and clinical practice guidelines aimed at reducing VAP have been available for many years. However, there is little clear evidence to guide the choice of interventions aimed at decreasing the incidence of VAP, and moreover, interventions differ among studies. Since 2004, the Institute for Healthcare Improvement (IHI) has recommended that all ICUs implement a ventilator bundle to reduce the VAP rate as part of its 5 Million Lives campaign. The IHI bundle, comprising 4 key components—head of bed elevation, peptic ulcer disease prophylaxis, deep venous thrombosis prophylaxis, and daily sedation-vasication—has demonstrated effectiveness. However, some components are not easy to accomplish in resource-limited intensive care units (ICUs), and other effective strategies, such as oropharyngeal care with chlorhexidine, are missing.

We have modified the components of the IHI bundle and reconstructed a VAP bundle. The present study examined the rate of VAP in ICUs after initiation of the VAP bundle compared with the VAP rate in the preceding 8 months.
METHODS
Setting and study design
This study was conducted in 6 Korean university hospitals with similar VAP rates. All of the hospitals were participants in the Korean Nosocomial Infections Surveillance System (KONIS), and thus had been conducting VAP surveillance before study initiation. This surveillance was maintained throughout the study. A total of 196 ICU beds were involved.

Although the VAP bundle was not implemented in any hospital at the start of the study, some of the elements were already in use in the ICUs, albeit not as a part of a bundle. Thus, we first investigated the performance of the separate VAP bundle interventions over the month before implementation of the VAP bundle.

Our VAP bundle comprised head of bed elevation, peptic ulcer disease prophylaxis, deep venous thrombosis prophylaxis, and oral decontamination with chlorhexidine 0.12%. Continuous aspiration of subglottic secretions (CASS) was an option, because it requires a specific endotracheal tube that is expensive and in short supply in Korea.

An infection control practitioner evaluated each patient in each ICU daily to check compliance with each bundle component. Head of the bed elevation was checked every 4 hours and considered done if checked "yes" all 6 times. Peptic ulcer disease prophylaxis was considered done if an H1 blocker, proton pump inhibitor, or sucralfate was given daily. Deep venous thrombosis prophylaxis was considered done if low-dose heparin, compression stocking application, or pneumatic compression was provided daily. Oral decontamination with chlorhexidine 0.12% was verified every 8 hours and considered done if checked "yes" all 3 times. CASS was considered done if the specialized endotracheal tube was used and suction was performed appropriately.

We educated all of the ICU teams, including 23 doctors and 318 nurses, on VAP, the importance of the VAP bundle, and need to follow the protocol for each bundle element. After the first month, the VAP bundle was implemented for 4 more months. Compliance with bundle elements was recorded daily using a checklist, and all interventions were monitored by infection control practitioners. Nurses intervened in this process at the time of monitoring if noncompliance with a bundle element was detected. Regular feedback on compliance was provided to the ICU teams. Given the time limitations of the study period, the VAP rate after implementation of the VAP bundle was compared with the rate in the previous 8 months. All study procedures were approved by the Institutional Review Board of each hospital.

Definitions
VAP surveillance was performed by trained infection control professionals using the previous US Centers for Disease Control and Prevention (CDC) definition, because this study was performed in early 2011. VAP was defined by the presence of new or progressive infiltrates on chest X-ray with no other obvious cause in patients receiving mechanical ventilation for more than 48 hours in the ICU, along with at least 2 of the following: temperature ≥ 38°C or ≤ 35°C, leukocytosis (white blood cell count [WBC] > 12,000/mm³) or leukopenia (WBC < 4,000/mm³), purulent endotracheal secretions, potentially pathogenic bacteria isolated from the endotracheal aspirate, and increasing oxygen requirement. Data on the development of VAP were collected by the same infection control practitioner throughout the study, and the incidence of VAP was expressed as cases of VAP per 1,000 ventilator-days. VAP surveillance had been performed in all 6 hospitals years before starting the study, and was continued throughout the study in the same way.

Statistical analysis
The effects of the VAP bundle were analyzed based on the incidence density ratio (rate). Baseline characteristics were compared using the χ² or Fisher’s exact test for categorical variables.
and the t-test for continuous variables. A P value <.05 was considered to indicate statistical significance.

RESULTS

Compliance with the VAP bundle

Overall compliance with the VAP bundle (except CASS) improved after implementation of the intervention, from 41.1% to 71.8%. Individual bundle items also showed improvement during the study period (Fig 1). Oral decontamination with chlorhexidine 0.12% was initially the most deficient (45.6%), but it improved greatly by the end of the study (91.6%). Compliance with peptic ulcer disease prophylaxis was initially high (83%) and decreased slightly (81.1%) after bundle implementation. Compliance with head of bed elevation (65.9%) improved slightly (72.9%), as did compliance with deep venous thrombosis prophylaxis (from 65.6% to 77.3%). There was no data on CASS use before the study, but compliance with CASS increased to 10% after bundle implementation.

Incidence of VAP

Before study initiation, there were 57 cases of VAP during the 8-month period from July 2010 through February 2011, for an incidence rate of 4.08 events/1,000 ventilator-days. After study initiation, 7 cases of VAP were detected between March 2011 and June 2011, for an incidence rate of 1.16 events/1,000 ventilator-days. The incidence density ratio (rate) was 0.28 (95% CI, 0.275-0.292) (Table 1).

DISCUSSION

Evidence-based guidelines for preventing nosocomial pneumonia have been published by the CDC since the 1980s12 and have contributed to a reduced incidence of VAP.13 The use of a care bundle, a set of key interventions based on the guidelines, can facilitate guideline implementation. In a large multicenter study, implementation of the VAP bundle, with a compliance rate of >95%, was associated with a significant reduction in VAP. Other studies have also reported a reduced VAP rate with the use of similar care bundles.8,9,14-15 However, there is some discordance regarding specific bundle components,16,17 and some investigators have argued against the use of VAP bundles.18

The present study demonstrates a reduction in VAP incidence after implementation of a VAP bundle. The VAP rate decreased from 4.08 events/1,000 ventilator-days in the 8 months before study initiation to 1.16 events/1,000 ventilator-days after initiation. The incidence density ratio (rate) was 0.28 (95% CI, 0.275-0.292), which means that the VAP incidence decreased by 0.28-fold.

Compliance with the bundle generally increased throughout the study period. Of the individual bundle elements, compliance with oral decontamination with chlorhexidine 0.12% had the greatest impact on VAP reduction. Compliance with this intervention was initially very low, but demonstrated the greatest improvement during the study. Previous studies have shown that using 0.12% chlorhexidine solution reduced the incidence of nosocomial pneumonia.19,20 However, other studies failed to demonstrate a positive effect of oral chlorhexidine.21-23 Our results potentially support the use of chlorhexidine as a bundle component for preventing VAP, but more evidence is needed. Generally, good compliance was demonstrated for all other bundle elements except CASS. Compliance with peptic ulcer prophylaxis actually decreased slightly during the study period, but this decline apparently had no effect on our results. Although our bundle did not include a daily sedation vacation, which is recommended by the IHI, it was still able to effect a significant reduction in VAP rate.

This study has some limitations. First, the study period was relatively short compared with previous studies; however, the multicenter design, with 6 university hospitals including 196 ICU beds, helped compensate for this limitation. Second, compliance with CASS was very low. CASS requires specialized, expensive endotracheal tubes and more time for tube manipulation and maintenance of suction lumen patency. For this reason, CASS was an optional component of our VAP bundle, and compliance with CASS was very low, as expected. Although the effect of CASS is very limited in this study, previous studies have found an association between CASS and a decreased VAP rate.24-26 Inclusion of CASS in the VAP bundle may decrease the VAP rate even further.

CONCLUSION

Proper application of the VAP bundle can decrease the incidence of VAP in patients receiving mechanical ventilation. This study is the first Korean multicenter research to evaluate the effectiveness of the VAP bundle.

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