Research Paper

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# Prevention of Ventilator-Associated Pneumonia in a Middle Eastern University Hospital: the Effect of care bundle Implementation

Medicine

KEYWORDS : Ventilator-associated pneumonia, Care bundles, Quality improvement, Infection control.

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## ABSTRACT

*Background: Ventilator-associated pneumonia (VAP) is a serious health care-acquired infection that occurs in up to 30% of mechanically ventilated patients and leads to prolonged mechanical ventilation, increased hospital stay, and mortality. The aim of this study was to establish the effects of implementing a VAP prevention bundle on VAP rates, antibiotic use, duration of mechanical ventilation, and intensive care unit (ICU) length of stay.*

*Design & Setting: This study used a before-and-after structure to analyze the effects of implementing a VAP prevention bundle in the surgical ICU of a Middle-Eastern university hospital*

*Interventions: A ventilator-associated pneumonia care bundle, consisting of 30o head-of-bed elevation, oral chlorhexidine, continuous aspiration of subglottic secretions (CASS), daily sedation hold, and daily assessment for weaning.*

*Results: During the pre-implementation phase, 323 patients were included in the study and 306 were included in the post-implementation phase. Compliance was 95% for the 30o head-up tilt and the oral chlorhexidine, 85% for the CASS, 75% for the daily sedation hold and assessment for weaning, and 70% for all five elements of the bundle. Rates of microbiologically confirmed VAP were 14 per thousand ventilator days in the pre- implementation period and 5 per thousand ventilator days in the post-implementation period (p=0.047). The mean length of time of antibiotic therapy was lower in the post-implementation phase but not reaching statistical significance. There was a significantly shorter duration of mechanical ventilation in the post-implementation phase (p=0.01).*

*Conclusion: VAP care bundle is an effective measure for lowering VAP rates in the ICU.*

**Introduction**

Ventilator-associated pneumonia (VAP) is a serious health care-acquired infection that occurs in up to 30% of mechanically ventilated patients.1VAP is defined as pneumonia occurring more than 48 h after the initiation of mechanical ventilation.2The Centers for Disease Control and Prevention of the National Healthcare Safety Network Hospitals have reported a mean VAP density varying from 10 to 41.7 cases/ 1000 ventilator days in developing countries.3,4The occurrence of ventilator-associated pneumonia (VAP) prolongs mechanical ventilation, increases the duration of hospital stay, and increases patient mortality. It is also associated with a higher cost.5

Strategies to improve patient outcomes in the intensive care unit (ICU) include the implementation of safety tools such as rapid response teams, daily goal sheets, and checklists. Another recent approach to facilitating guideline implementation involves the development of care bundles with implementation measures.

Implementing care bundles in clinical practice has been widely advocated in mechanically ventilated patients admitted to intensive-care units and is associated with a reduced risk of VAP.6

A care bundle identifies a set of key interventions derived from evidence-based guidelines that, when implemented, are expected to improve patients' health outcomes7,8.

The aim of care bundles is to improve health outcomes by facilitating and promoting changes in patient care and to encourage guideline compliance.

The most important change remains a cultural emphasis that errors should be considered a failed system rather than people failure as harm is often the result of a cascade of broken systems9.

Several clinical interventions have been found to reduce the incidence of VAP, including elevation of the head of the bed, a daily sedation break, a daily trial of ventilator weaning, and topical oral chlorhexidine10. The quality of evidence supporting the effectiveness of each intervention and the relative importance of each has been questioned11. VAP incidence has become a quality indicator in many healthcare systems, leading to comparisons between ICUs. The "VAP prevention bundle" is a central component of most critical care patient safety programs11.

As part of our university hospital's effort to improve patient care and prevent hospital acquired infections, this study was undertaken to focus on VAP prevention as a quality improvement initiative. We hypothesized that reliable implementation of, and compliance to a VAP prevention care bundle would decrease the VAP rate in our ICU.

The aim of this study was to establish the effects of implementing a VAP prevention bundle on VAP rates, antibiotic use, duration of mechanical ventilation, ICU length of stay, and patient mortality in a 14 bed university hospital ICU.

**Methods**

The study was conducted in the surgical Intensive Care Unit, of a University affiliatedhospital. As a service evaluation and quality improvement project, ethics committee approval was not required. The study used a before-and-afterstructure to analyze the effects of implementinga VAP prevention bundleon the incidence of clinical and microbiological VAP in mechanically ventilated critically ill patients.The study covered a one year period and was divided into a 6 month pre-implementation period during which standard care for mechanically ventilated patients was used and auditedand a 6 month post-implementation period during which a VAP care bundle was implemented and audited. All adult patients meeting the inclusion criteria were recruited to the study. The inclusion criteria were; age above 18 years, intubated and mechanically ventilated patients.The exclusion criteria were; patients intubated prior to admission to the ICU, ICU length of stay less than 48 hours, and tracheostomized patients.

**Procedure**

**During the pre- implementation period:**all enrolled patientsreceived standard care for mechanically ventilated patients consisting of:

- Elevation of the head of bed to 30 degrees or more.

- Daily mouth care using oral hygiene kits

**During the post-implementation period:** patients received a VAP prevention bundle previously developed by the Scottish Intensive Care Society Audit Group for the Scottish Patient Safety Program 12 as follows:

**1. Sedation reviewed and, if appropriate, stopped each day**

- Sedative was stopped, but not disconnected from the patient.

- Patient was allowed to wake.

- If the patient was cooperative and able to understand commands sedation wasleft off.

- Distressed or agitated patients were re-sedated.

- Sedation was restarted at half the previous rate.

- Boluses were administered as appropriate.

**Exclusions**

- Paralyzed patients

- Patients with brain injury or raised ICP

- Patientsdifficult to ventilate

- Patients difficult to oxygenate

- Patient receiving palliative care

**2. All patients were assessed for weaning and extubation each day**

**Exclusions**

- Paralyzed patients

- Patients with brain injury or raised ICP

- Patients difficult to ventilate

- Patients difficult to oxygenate

- Patient on palliative care

**3. All patients were placed in at least 30° head up position**

**Exclusions**

- Shocked patients

- Patients on high dose inotropes

- Patients with unstable pelvic or spinal injury

- Patients on palliative care

**4. Daily mouth care was performed using chlorhexidine gel ( 2 %)**

Chlorhexidine gel was applied with a clean glove donned for the application

**Exclusions**

- Oro-pharyngeal trauma or surgery

- Hypersensitivity to chlorhexidine

**5. Continuous aspiration of subglottic secretions**

- Endotracheal tube with subglottic drainage port was inserted for all patients and subglottic aspiration ports were aspirated continuously.

**Exclusions**

- Patients intubated prior to ICU admission

- Patients receiving palliative care

Methods used during implementation of the care bundle included teaching materials for physicians and nurses, education sessions, and bedside cues. All modifications to improve compliance were led by nursing and medical staff.

**VAP diagnosis:** A diagnosis of VAP was established using the Hospitals in Europe Linked for Infection Control through Surveillance (HELICS)[13] two-stage definition consisting of clinically suspected VAP based on clinical criteria andmicrobiologically confirmed VAP based on further investigations.

**I. Clinical VAP was diagnosed according to the following criteria:**

1. Radiological changes: a chest X-Ray or CT scan suggestive of pneumonia (2 or more required for patients with underlying cardiac or pulmonary disease) and at least one of the following

2. Systemic inflammation : white cell count of > 12,000/mm3 or <4000/mm3 or temperature > 38oC with no other cause and at least one of the following (two required if microbiology is by qualitative endo-tracheal aspirate culture or culture are negative)

3. Clinical pulmonary signs :

- New onset of purulent sputum, or

- Change in character (color, odor, consistency, or quantity), or

- Cough, dyspnea, or tachypnea, or

- Auscultatory findings (rales, bronchial breathing, rhonchi wheeze), or

- Worsening gas exchange (e.g. Desaturation, increasing $FiO_2$ , or ventilator requirements)

**II. Microbiological VAP was diagnosed according to the following criteria:**

- Positive quantitative culture from minimally contaminated lower respiratory tract samples (i.e. growth at > 104 CFU/ml from bronchoalveolar lavage (BAL) cultures, or

- Positive blood cultures without another source

- Positive pleural fluid culture

- Pleural or pulmonary abscess with culture positive needle aspirate

- Histological evidence of pneumonia, or

- Positive qualitative culture of endo-tracheal aspirates or non-directed mini BAL

Negative cultures meeting clinical criteria above were recorded as clinical VAP

Data were collected on the following:

**1. Patient Characteristics:** Age, Gender, Intensive care unit

admission diagnosis, admission Acute Physiology and Chronic Health Evaluation II score ,ICU length of stay, Duration of mechanical ventilation, days of antibiotic therapy, hospital outcome

**2. VAP Bundle compliance**
Compliance to the VAP Bundle was audited weekly at varyingtimes by a nurse who audited chartsfrom the previous day to minimize bias. Compliance was defined asclear documentation confirming adherence to the bundle.

**3. Clinicallydiagnosed VAP rate/ 1000 ventilator days**
**4. Microbiologically confirmed VAP rate/ 1000 ventilator days**
**6. Microbiological etiology of VAP acquired during the study**
**Statistical analysis:**
Data was computed using SPSS (Statistical Package for Social Sciences Version 16). Summary statistics using Z-test tocompare proportions, Mann-Whitney Utest to compare median values, and Poisson regressionfor incident densities. Changes were also assessed using statistical process control charts using monthly data throughout the period of observation. Patient gender, age, and admission Acute Physiology and Chronic Health Evaluation II score were compared as potential confounders to a before-and-after evaluation.

**Results:**
During the pre-implementation period, 734 patients were admitted and mechanically ventilated, of whom323 required ≥48hrs in the ICU (44% patient at-risk rate). During the post-implementation period, 649 patients were admitted, of whom 306 required ≥48hrs in the ICU (47% patient at-risk rate). There were no statistically significant differences between patients recruited during the pre-implementation phase and those recruited during the post-implementation phase as regards age, gender, or admission APACHE II score. During the post-implementation period compliance with the 30-degree head-up tilt was consistently 95%. Compliance with oral chlorhexidine was 95%. Compliance with CASS was 85%. Compliance with the sedation hold and daily assessment for weaning was 75%. Compliance with all five elements of the bundle was achieved in 70% of patients (Figure 1).

**PLACE FIGURE (1) ABOUT HERE**
The clinically suspected VAP rate before implementation was 15% (48 VAP events) compared with 9% (27events) during the post-implementation phase (absolute risk reduction, 6%; 95% confidence interval [CI]; relative risk reduction, 40%; 95% p ≤0.02) (Table 1). The rates of microbiologically confirmed VAP also decreased in the post-implementationphase 4% (12 VAP events) compared to 14% (29 VAP events) in the pre-implementation phase (absolute risk reduction, 5%; 95% confidence interval [CI]; relative risk reduction, 56%; 95% p ≤0.01).

**PLACE TABLE (1) ABOUT HERE**
The proportion of cases diagnosed by bronchoscopy was approximately the same in the two groups. The pathogens causing microbiologically confirmed VAP are shown in Table (2). The mean length of time of antibiotic therapywas notably lower in the post-implementation phase than the pre-implementation phase; however, the difference did not reach statistical significance. There was a statistically significant difference in the duration of mechanical ventilation (6.16(3.55) days in the pre-implementation phase compared to 4.03 (2.26) days in the post-implementation phase p=0.01).

**PLACE TABLE (2) ABOUT HERE**
The ICU length of stay was comparable in the two phases of the study. The rates of MRSA Infection decreased from 3% of patients in the pre-implementation phase to 1% in the post-implementationphase without however reaching statistical significance. There was no statistically significant difference in mortality rates between the pre- implementationphase (24%) and the post-implementation period (20%). Figure (2) shows a "run-chart" illustrating monthly rates of clinically suspected VAP per 1000 ventilator days over the entire period of data collection this shows a marked decrease duringthe post-implementation period.

**PLACE FIGURE (2) ABOUT HERE**
**Discussion:**
Our study demonstrated that the implementation of a VAP prevention bundle can result in a significant reduction in the incidence of VAP when the compliance levels are high. Wip and Napolitano14 suggested that the respiratory care bundle was an effective method to reduce VAP density in ICUs, but should be modified and expanded to include effective and evidence-based practices with a focus on VAP prevention.

We undertook this study in the surgical intensive care unit of our university affiliated hospital due to the notably high rates of VAP in our institution. Consequently, we felt an urgent need to implement a VAP care bundle due to the inconsistencies in the previous care regimens applied to mechanically ventilated patients. This required the involvement of all the intensive care unit team.

The elimination of hospital acquired infections is now being considered a priority in many hospitals worldwide.15,16 However, in middle eastern hospitals, strategies to effectively prevent VAP have not yet been fully implemented. We believe that, in order to control VAP in the ICU, it is not sufficient to implement one measure, but rather to introduce a culture change that involves the education of the whole ICU team about the prevention of VAP and the careful monitoring of the compliance to the VAP prevention strategies. Several studies have shown that the participation of a multidisciplinary team is associatedwith a decrease in nosocomial infections andVAP.17,18

We chose to implement a bundle consisting of five elements; 30o head up position, daily mouth care with chlorhexidine gel (2%), continuous aspiration of subglottic secretions, daily sedation review, and daily assessment for weaning and extubation. This regimen was derived from the bundle developed by the Scottish Intensive Care Society Audit Group for the Scottish Patient Safety Programme12. We elected not to include peptic ulcer prophylaxis or DVT prophylaxis in our VAP bundle since these regimens are already part of our standard regimen for management of critically ill patients.

A number of studies have demonstrated that gastric reflux and aspiration of gastric contents can be prevented with a semi upright position in patients on mechanical ventilation.19,20,21 This is because, when receiving enteral nutrition, a supine position facilitates patient's aspiration of subglottic secretions.22,23This has been demonstrated in a prospective clinical study of critically ill patients, who remained in a 30o head up position for the first 24 hours of mechanical ventilation, and had a lower incidence of VAP compared with patients positioned at less than 30o.Other investigationshave shown that the elevation of the HOB at 45oat all times might not be feasible.24,25

We also included oral decontamination with chlorhexidine 2% as part of our VAP bundle. The use of chlorhexidine in varying concentrations (0.12%,0.2%, and 2%) has been studied in different ICU patient populations, with varying results.26,27Some studies using lower concentrations of chlorhexidine have concluded that chlorhexidine only delays the development ofVAP, as it had no benefit in mortality, days of mechanical ventilation, and other patient outcomes. While whenhigher concentrations were used (2%) therewere significant reductions in VAP rates.28

We also included the continuous aspiration of subglottic secretions (CASS) in our study since oropharyngeal bacterial colonization and mircoaspirationof subglotic secretions are importantmechanisms for developing VAP.29,30This involves the insertion of an ETT with an additional dorsal channel to allow the continuousaspiration of subglottic secretions (Mallinckrodt™ SealGuard™ Evac,).

The use of a subglottic secretion ETT showed a decrease in the incidence of early VAP in a previous study.31Several other publications have also reported the utility of the CASS endotracheal tube in reducing VAP32,33incidence.

Excessive use of sedation in the ICU typically leads to side effects, including gastrointestinal motility disturbances and difficulty weaning from the ventilator. Prolonged intubation further increases the exposure to risk factors for infection, microaspiration, gastrointestinal motility, and microcirculatory disturbances.34,35

The use of theleast amount of sedation possible has beenshown to decrease the number of ventilated days, and ICU mortality36

Although no studies have shown a decreasedrate of VAP directly related to an intermittentsedation strategy, however, the use of the least amount of sedation may contribute to early extubation. For this reason it has been advocated that all intubated patientshave daily sedation interruptions iftheir clinical condition allows.37

Previous studies have shown that pursuing a protocol for early extubationis associated with shorter duration of mechanical ventilation.38A shortened time of mechanical ventilation and therefore decreased time of ETT exposure reduces the risk of aspiration of contaminated secretions and the likelihood of developing VAP39

Some practices have been advocated in other VAP bundle regimens which we elected not to include in our study, such as selective digestive decontamination (SDD) due to our concern about the associated risk for selection of multi resistant pathogens, and the increase in colonization rates and infection with Enterococcus and methicillin-resistant Staphylococcus aureus (MRSA) which have been demonstrated in previous studies.40, 41

Other studies have advocated the use of silver coated ETT due to the prevention of biofilm formation42which has been shown to occur as early as 24 hours after intubation43 These biofilms are viscous and adherent in nature and offer mechanical protection to bacteria.44However, these silver coated tubes were not available in our hospital, and thus were not included in our bundle.

The implementation of our VAP bundle resulted in a reduction in the VAP rates in our hospital (relative risk reduction 56%), we were able to achieve a compliance rate of 70% for all the bundle elements after actively implementing the VAP bundle protocol. These findings were consistent with previous studies45 that noted improved compliance once VAP prevention measures were actively rather than passively implemented. Along with the notable decrease in VAPrates , we were also able to demonstrate a significant reduction in the duration of mechanical ventilation (p= 0.01). We were however unable to achieve full compliance with the sedation hold or the daily assessment for weaning elements of the VAP prevention bundle, this may be due to the fact that compliance with this bundle element is strongly influenced by variations in patient conditionsmore than other elements of the bundle.

In a similar study, Morris et al were able to demonstrate levels of compliance that were close to 100%. They were also able to demonstrate clear benefits to patients.46Our approach, on the other hand, advocates that there is a possibility that lower thresholds for compliance with a care bundle may still offer benefit in patient outcomes which supports the general approach that applying quality control measures can lead to true improvements in outcomes.

The combination of decreased frequency and duration of antibiotic use indicates a direct effect on drug cost. We were, however, not able to achieve a statistically significant reduction in duration of antibiotic therapy this may be due to the relatively short duration of our study. A similar quality control study conducted by Morris et al achieved results indicating a reduction of antibiotic use insubgroups with longer ICU stays.46Theirstudy was however conducted over a 4 year period and included a cohort of more than 2000 patients. We also noted a lower rate in the acquisition of MRSA (7 in the pre-implementation period compared to 3 in the post-implementation period) that was consistent with previous studies.47 However the small number of MRSA cases did not allow us to obtain a large enough sample in order to compare the two groups.

Management of VAP requires a balance between early treatment with empirical broad spectrum antibiotics and focused therapy based on the results of cultures. The delay in obtaining microbiological results and the subsequent resorting to empirical antibiotics may be associated with adverse outcomes48. As a result, clinically suspected VAP that may prove to be unconfirmed microbiologically still offers an antibiotic burden. For this reason our reduction in antibiotic use, while not statistically significant, is still considered promising and requires further studies including larger patient samples.

There remain a number of VAP reduction interventions that we have not yet adopted, such as antibacterial-coated endotracheal tubes49and selective bacterial decontamination. These, combined with more complete adoption of the wake and wean bundle elements, may allow us to achieve further improvements in patient outcomes.

In general, it is commonly accepted that a heavy change in daily practice would take a while until it achieves its final goal. Our study confirms what was suggested by Resaret al. that a 'changed delivery system' and 'chain reaction' of increased attention to the patients leads to benefits in patient outcomes.50

**Conclusion:**

The implementation of a VAP care bundle proved to be an effective measure for lowering the VAP incidence in our ICU. Continuous compliance to quality improvement protocols will result in benefits in our ICU patient outcomes.

**Acknowledgments**

We thank all members of the infection control unit and all Surgical ICU staff who dedicated their efforts to collect data and complete all bundle care regimens.

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**Table (1) Demographic Data for Patients included in the study before and after the implementation of the VAP care Bundle**

| Ventilated patients requiring ICU stay ≥48 hrs | Pre-implementation | Post-implementation | P |
|---|---|---|---|
| Nº | 323<br>275<br>294 | 306<br>279<br>294 | |
| Age, median (IQR) | 58 (43–71) | 59 (42–69) | 0.6 |
| Male (%) | 59 | 63 | 0.46 |
| APACHE II, median (IQR) | 23 (17–27) | 22 (16–28) | 0.22 |
| Clinical VAP, No. (%) | 48(15) | 27(9) | 0.002* |
| Rate/1000 ventilator days | 31 | 11 | 0.002* |
| Microbiologically confirmed VAP, No. (%) | 29(9) | 12(4) | 0.001* |
| Rate/1000 ventilator days | 14 | 5 | 0.047* |
| Diagnosed by bronchoalveolar lavage (%) | 19 | 17 | 0.051 |
| Mortality, No. (%) | 77(24) | 60(20) | 0.19706 |
| Length of stay, days, mean(SD) | 7(3.57) | 6.46 (3.2) | 0.6 |
| Duration of ventilation, days mean (SD) | 6.16(3.55) | 4.03 (2.26) | 0.01* |
| Days of antibiotic therapy mean (SD) | 6.3 (2.85) | 5.2 (3.01) | 0.136 |

*statistically significant at p≤0.05

APACHE, Acute Physiology and Chronic Health Evaluation; ICU, intensive care unit; IQR, interquartilerange; SD, standard deviation; VAP, ventilator-associated pneumonia.

**Table 2. Microbiological Etiology of the Ventilator-Associated Pneumonias Acquired During the Study Period**

| Microorganism | Pre-implementation | Post-implementation |
|---|---|---|
| Gram-positive | | |
| Staphylococcus aureus (methecillin-resistant) | 7(24%) | 3(25%) |
| Streptococcus sp. | 2 | 1 |
| Coagulase-negativeStaphylococcus | 1 | 0 |
| Gram-negative | | |
| Acinetobacterbaumannii | 2 | 0 |
| Citrobacter sp. | 1 | 0 |
| Enterobacteraerogenes | 0 | 1 |
| Enterobacter cloacae | 0 | 1 |
| Other Enterobacter sp. | 1 | 0 |
| Enterobacter sp. | 1 | 0 |
| Escherichia coli | 2 | 1 |
| Flavobacterium sp. | 0 | 1 |
| Haemophilus influenzae | 1 | 0 |
| Klebsiella pneumonia | 2 | 0 |
| Morexellacatarrhalis | 0 | 1 |
| Proteus vulgaris | 1 | 0 |
| Pseudomonas aeruginosa | 3 | 1 |
| Pseudomonas fluorescens | 1 | 0 |
| Serratiamarcesens | 1 | 0 |
| Fungi | | |
| Aspergillusfumigatus | 1 | 0 |
| Candida albicans | 1 | 2 |
| Candida glabrata | 1 | 0 |

Figure (1): VAP bundle compliance

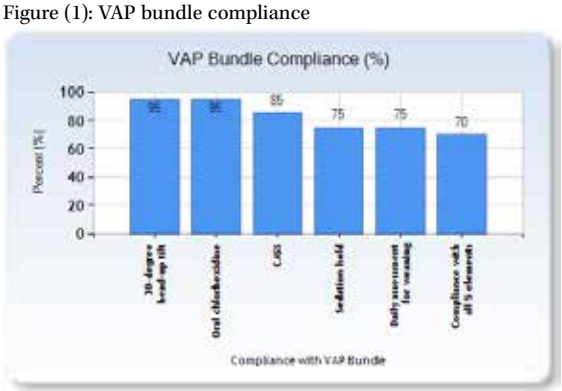
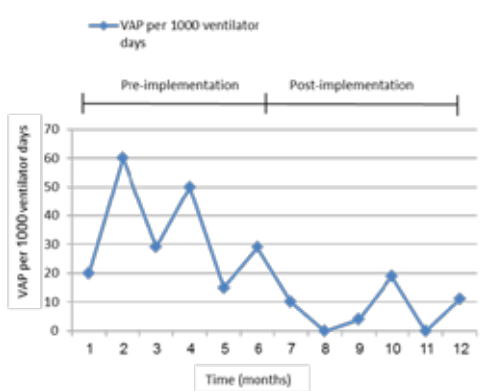



Figure (2)Run chart showing the incidence of clinical ventilator-associated pneumonia (VAP), expressed per 1000 ventilator days, on a month-by-month basis.



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