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Major article

The impact of implementing multifaceted interventions on the prevention of ventilator-associated pneumonia

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Background: Ventilator-associated pneumonia (VAP) is a frequent hospital acquired infections among intensive care unit patients. The Institute for Healthcare Improvement has suggested a "care bundle" approach for the prevention of VAP. This report describes the effects of implementing this strategy on VAP rates.

Methods: All mechanically ventilated patients admitted to the intensive care unit between 2008 and 2013 were prospectively followed for VAP development according to the National Healthcare Safety Network criteria. In 2011, a 7-element care bundle was implemented, including head-of-bed elevation 30°-45°, daily sedation vacation and assessment for extubation, peptic ulcer disease prophylaxis, deep vein thrombosis prophylaxis, oral care with chlorhexidine, endotracheal intubation with in-line suction and subglottic suctioning, and maintenance of endotracheal tube cuff pressure at 20-30 mmHg. The bundle compliance and VAP rates were then followed.

Results: A total of 3665 patients received mechanical ventilation, and there were 9445 monitored observations for bundle compliance. The total bundle compliance before and after initiation of the VAP team was 90.7% and 94.2%, respectively ($P < .001$). The number of VAP episodes decreased from 144 during 2008-2010 to only 14 during 2011-2013 ($P < .0001$). The rate of VAP decreased from 8.6 per 1000 ventilator-days to 2.0 per 1000 ventilator-days ($P < .0001$) after implementation of the care bundle.

Conclusions: This study suggests that systematic implementation of a multidisciplinary team approach can reduce the incidence of VAP. Further sustained improvement requires persistent vigilant inspections.

Ventilator-associated pneumonia (VAP) is one of the most frequent hospital-acquired device-associated infections among patients in the intensive care unit (ICU).[1,2] The reported incidence ranges from 8% to 68%,[3] with an overall attributable mortality of 13% in a recent systematic review[4] and even up to 76% in specific settings with high-risk pathogens.[5] Furthermore, the development of VAP is linked to an additional 9.6 days of mechanical ventilation (MV), 6.1 days of ICU admission, and more than $40,000 in hospital costs per patient.[6]

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In 2004, an Institute for Healthcare Improvement (IHI) campaign introduced the notion of a "care bundle" for the prevention of VAP.[7] A bundle is a structured approach to facilitating the application of best practices and evidence-based care for all patients, thereby improving patient outcomes.[7] Since the advent of care bundle, the frequency of VAP in the United States has been declining.[8] The Centers for Disease Control has reported a mean VAP rate of 3.6 cases per 1000 ventilator-days in ICUs in the United States[9]; however, recent data from the International Nosocomial Infection Control Consortium surveillance study show rates as high as 16.8 cases per 1000 ventilator-days in developing countries.[10] There remains an enormous need for quality improvement initiatives in many countries worldwide to prevent the morbidity and mortality attributed to this condition.

Despite improvement efforts that included the implementation of VAP prevention measures, active surveillance, and early detection, and the subsequent decline in VAP rates, VAP remained a substantial burden in our ICU.[9] The hospital administration viewed this as a "big dot" quality indicator, requiring a major focus of quality initiatives and patient safety efforts in our institution. Here we report the strategies implemented by the VAP prevention team and the rates of VAP in the adult ICU population before and after implementation of these strategies.

METHODS

Study design

The primary aim of this study was to evaluate the effectiveness of implementing a VAP prevention bundle by a multidisciplinary team in a before and after analysis. In 2008, our hospital's Infection Control Department implemented a VAP care bundle. Although this led to a reduction in VAP, the rates still remained above the National Healthcare Safety Network's benchmark of 2.1 per 1000 ventilator-days.[11] The goals of this project were to maintain a rate of bundle compliance >90% and reduce the VAP rate to ≤2.0 per 1000 ventilator-days. The Institutional Review Board and King Abdullah International Medical Research Center Ethics Committee of National Guard Health Affairs, Riyadh approved this study and waived the requirement for informed consent.

Setting and organization of the ICUs

This was a quality improvement project performed at King Abdul Aziz Medical City in Riyadh, Saudi Arabia, for all adult patients who received invasive MV in the ICU between January 1, 2008, and December 31, 2013. The ICU admitted approximately 900 patients annually and was covered by onsite board-certified intensivists 24 hours per day, 7 days per week, with a nurse:patient ratio of approximately 1:1 and a respiratory therapist:patient ratio of approximately 1:5. The hospital was a 1000-bed tertiary-care center accredited by The Joint Commission International, with an active Infection Prevention and Control Program that collaborated with the ICU medical and nursing staff to ensure the implementation and monitoring of infection control practices.

Team formation

As part of a quality improvement process in our institution, a multidisciplinary VAP team was created in January 2011 to implement evidence-based practices, including the ventilator care bundle. The focus group, led by an intensivist, included a multidisciplinary group of physicians, nurses, respiratory therapists (RTs), infection control practitioners, and quality management personnel. The goal of this team was to reduce the incidence of VAP.

Driver diagram

The VAP team had several meetings with representatives from the IHI. A driver diagram was constructed that illustrated the theory of change. A driver diagram is a tool to help organize theories and ideas in an improvement project that aims to identify the changes that will result in improvement (Fig 1).

Data collection

The VAP team monitors were trained in data collection and monitored bundle compliance on a daily basis during this project. They examined and reviewed the charts of all patients on MV in the ICU. Data were collected at different times of day (morning, afternoon, and night). If a component of the bundle was deemed noncompliant, the VAP inspectors used this moment to elucidate any barriers to the implementation of the particular element. This time also provided a teaching opportunity to educate staff.

The ICU had a "safety team" comprising physicians who randomly monitored the compliance with all ICU bundles on an almost-daily basis. Their data were compared with the VAP team data as a redundant check.

Diagnosis, definition, and classification of VAP

We defined VAP as pneumonia that developed more than 48 hours after endotracheal intubation. It was diagnosed clinically based on the Centers for Disease Control and Prevention criteria as 2 or more serial chest radiographs with at least 1 of the following: new, progressive, or persistent infiltrates; consolidation; or cavitation; with 2 of the following: core temperature ≥38.5 or ≤36°C, leukocytosis (≥12,000/mm^3), leukopenia (white blood cell count <1500/mm^3); or new-onset purulent bronchial secretions, without another cause and a significant positive culture from blood, bronchoalveolar lavage fluid, or endotracheal aspirate or culture from another relevant site of infection.[12] Tracheal aspirates were considered purulent at a neutrophil count with Gram stain of >25 per high-power field on light microscopy. Data on the development of VAP were collected by an independent investigator from the Infection Control Department. All patients with suspected VAP were reviewed prospectively and independently by 2 infectious diseases physicians, who confirmed the diagnosis. VAP surveillance had been performed since 2003 in the hospital and was continued throughout the study in the same way. The incidence of VAP was expressed as cases of VAP per 1000 ventilator-days.

VAP prevention care bundles

After several brainstorming sessions and plan-do-study-act cycles, we adopted a modified IHI VAP care bundle, as follows:

1. Head-of-bed (HOB) elevation 30-45°
2. Daily "sedation vacation" and daily assessment of readiness for extubation
3. Peptic ulcer disease (PUD) prophylaxis
4. Deep vein thrombosis (DVT) prophylaxis
5. Oral care with chlorhexidine solution
6. Adequate endotracheal tube cuff pressure (20-30 mmHg)
7. Endotracheal tube with and in-line suction system and subglottic suctioning.

HOB elevation

The hospital was equipped with Hill-Rom hospital beds (Hill-Rom, Chicago, IL). The angle of the HOB was measured with an electronic