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Major Article

Impact and feasibility of an emergency department–based ventilator-associated pneumonia bundle for patients intubated in an academic emergency department

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Background: Ventilator-associated pneumonia (VAP) has been linked to emergency department (ED) intubation and length of stay (LOS). We assessed VAP prevalence in ED intubated patients, feasibility of ED VAP prevention, and effect on VAP rates.

Methods: This was a quality improvement initiative using a pre/post design. Phase 1 (PRE1) comprised patients before intensive care unit (ICU) bundle deployment. Phase 2 (PRE2) occurred after ICU but before ED deployment. Phase 3 (POST) included patients received VAP prevention starting at ED intubation. Log-rank test for equality and Cox regression using a Breslow method for ties were performed. Bundle compliance was reported as percentages. Number needed to treat (NNT) was calculated by ventilator day.

Results: PRE1, PRE2, and POST groups were composed of 195, 192, and 153 patients, respectively, with VAP rates of 22 (11.3%), 11 (5.7%), and 6 (3.9%). Log-rank test showed significant reduction in VAP ($\chi^2 = 9.16$, $P = .0103$). The Cox regression hazard ratio was 1.38 for the Clinical Pulmonary Infection Score ($P = .001$), and the hazard ratio was 0.26 for the VAP bundle ($P = .005$). Bundle compliance >50% for head-of-bed elevation, oral care, subglottic suctioning, and titrated sedation improved significantly with introduction of a registered nurse champion. NNT varied from 7 to 11.

Conclusions: VAP was common for ED intubated patients. ED-based VAP prevention is feasible. We demonstrate significant reduction in VAP rates, which should be replicated in a multicenter study.

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Conflicts of interest: None to report.

Author contributions: L.A.D. is the principal author and has access to all of the data, led all phases of design, data collection, and analysis, and assumes responsibility for the work as a whole. L.A.D. and D.D.D. wrote the initial draft of the manuscript. L.A.D., P.W., D.D.D., L.R.S., L.M.Y., K.J.H.G., M.J.G., W.J.L., U.S., D.M.S., and K.R.D. contributed significantly to revisions of the manuscript. W.J.L., M.J.G., and L.R.S. were responsible for manuscript sections on bundle compliance and team dynamics.

D.D.D. and U.S. (with assistance from collaborators A.T. and E.G.) performed the initial incidence/mortality analysis. P.W. performed the survival analysis, performed substantial revisions to the article, and provided significant input on improving statistical methods. L.A.D., K.J.H.G., L.R.S., M.J.G., and L.R.S. were responsible for faculty and staff education and training and development of the curriculum and assessment instruments. L.A.D., L.M.Y., and D.D.D. were responsible for development of the ventilator-associated pneumonia diagnostic algorithm, with significant assistance from collaborators B.M., D.S., and E.G.

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Ventilator-associated pneumonia (VAP) is defined as a new pneumonia presenting ≥48 hours after intubation. VAP increases the duration of mechanical ventilation and doubles mortality.[1-3] Prehospital or emergency department (ED) intubation and prolonged ED stays are associated with a much higher rate of VAP than intubation in the intensive care unit (ICU).[4-6] Strenuous efforts to reduce the incidence of VAP have been carried out in ICUs nationwide. These efforts typically involve a series of consistently applied straightforward evidence-informed practices termed VAP reduction bundles or simply VAP bundles.[7] These VAP bundles have led to substantial incremental improvement in VAP rates.[8-15] Although VAP is generally diagnosed in the ICU, the risk of developing VAP begins at the time of intubation. This begs the question of whether introducing these same practices to the ED would achieve additional improvement in VAP rates.

Although it is reasonable to intuit that earlier initiation of VAP prevention efforts may improve VAP rates, it remains unproven that ED-based VAP prevention will further reduce VAP over ICU-based efforts. Early work has described the development of an ED VAP reduction bundle, but it was underpowered to show differences in VAP outcomes.[16] Given the labor-intensive nature of implementing VAP prevention, it is important to ensure that such interventions are both feasible to implement and substantially decrease VAP rates before widespread deployment in the ED setting.

We hypothesized the following:

1. VAP is sufficiently prevalent in patients intubated in the ED to warrant prevention efforts. We defined sufficiently prevalent as occurring in >2% of patients intubated in the ED.
2. VAP reduction bundle implementation is feasible in the ED. We defined feasible implementation as 50% frequency of a given bundle component being performed.
3. ED-based VAP prevention would decrease the risk of VAP among patients intubated in the ED, in particular early VAP occurring within the first week of intubation.

MATERIALS AND METHODS

Study design

This was a natural experiment that we nested in a quality improvement (QI) initiative in an academic ED with an annual census of 77,000.

The project was reviewed by our institutional review board and classified as exempt.

Study protocol

Outcomes

We retrospectively measured VAP rates before and after ICU implementation of a VAP bundle. These patients were consecutively identified from two 6-month periods in July-December 2007 (PRE1) and June-November 2009 (PRE2) using an existing database of patients intubated in the ED. We then prospectively measured VAP rates after ED implementation of the identical bundle from May 2012-July 2013 (POST). Prehospital intubations were excluded. Between the PRE2 and POST periods, no changes were made to the ICU VAP prevention program. We also prospectively measured compliance with the VAP bundle components in the POST period. ED VAP bundle compliance was assessed from time of intubation in the ED until transfer to ICU.

VAP bundle

The VAP bundle comprised head-of-bed elevation to 30°-45°, oral care every 2 hours, subglottic suctioning, sedation titration (bolus dosing, drip rate adjustments, or documentation of Richmond Agitation Sedation Scale score), sedation vacations and spontaneous breathing trials (SBTs) as appropriate, deep vein thrombosis prophylaxis, and stress ulcer prophylaxis. Compliance was measured by chart abstraction from nursing notes, supplemented by direct observation during patient care rounds at change of shift and as part of bedside teaching by the registered nurse (RN) champion. ED VAP prevention order sets were linked to existing ICU order sets; therefore, a single set of interventions was used throughout the hospital. Between the PRE2 and POST periods, the Mallenckrodt tube with TaperGuard balloon (Covidien, Dublin, Ireland), was deployed for all nonoperating room intubations. Between the PRE2 and POST periods, a new bed tower was constructed, and the ED and ICUs were moved into the new tower. Although this move resulted in both an increase in number of ED and ICU beds, nurse and patient care technician staffing ratios remained the same. There were no significant changes in ICU order sets for VAP prevention between the PRE2 and POST periods. A transition occurred in late 2010 to computer-based ordering from a paper-based system, but the paper-based order sets were carried over without change.

We trained the ED staff in our VAP prevention bundle. We developed VAP supply carts and strategically positioned them in the ED. The VAP bundle was initiated at the time of intubation.[17] VAP bundle compliance was assessed from time of intubation until transfer to the ICU. For a subset of patients in the POST group, an ED RN champion was present to provide real-time mentoring and feedback to nursing staff and to facilitate compliance.

Measures: Diagnosis and definition of VAP

We diagnosed VAP using the algorithm shown in Figure 1. Patients could be diagnosed with VAP if they were alive and still intubated at 48 hours and had not developed a new pneumonia within the first 48 hours of intubation. Although all intubated patients appear to have the potential to develop VAP, the reality is that a substantial portion may not still be intubated at 48 hours, and it is usually not known at the time of intubation who will be extubated within 48 hours. Therefore, we assessed the VAP rates both for the overall cohort and for those who remained intubated at 48 hours. We term this group the at-risk subset; however, they cannot be known at the time of intubation.

These at-risk patients were diagnosed with VAP if they had a new, persistent infiltrate on chest x-ray after ≥48 hours of continuous mechanical ventilation, temperature >38°C or <36°C, and leukocytes >12,000 or <4,000, or microbiologic evidence of VAP (eg, growth of a predominant organism on bronchoalveolar lavage). Discharge summaries, microbiologic data, and antibiotic therapy were reviewed to confirm the diagnosis. The VAP diagnostic algorithm was developed and iteratively tested prior to formal data analysis.

Patients who had a significantly abnormal CXR at the time of intubation that would obscure a subsequent diagnosis of VAP were excluded from the at-risk subset, which was defined as radiologist interpretation of possible infectious etiology or significant abnormality (eg, large pulmonary contusion, significant pulmonary edema) that might obscure an existing pneumonia. Intubation duration was determined by reviewing flow sheets with granularity to the hour. Mortality was defined as proportion of patients who died prior to hospital discharge.

ICU illness severity scores were calculated from the first 24 hours after ED presentation. Ventilator days, ED length of stay (LOS), ICU LOS, hospital LOS, in-hospital mortality, and Clinical Pulmonary Infection Scores (CPISs) were calculated for each patient. The reason for the respiratory failure was determined for each patient by review of the ED chart and was abstracted from the ED diagnoses and the intubation note, which provided a stated reason from the treating clinician(s) for the respiratory failure that led to the intubation. For