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Original Research

CRITICAL CARE

The Clinical Impact and Preventability of Ventilator-Associated Conditions in Critically Ill Patients Who Are Mechanically Ventilated

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Background: **Ventilator-associated conditions (VACs) and infection-related ventilator-associated complications (iVACs) are the Centers for Disease Control and Prevention's new surveillance paradigms for patients who are mechanically ventilated. Little is known regarding the clinical impact and preventability of VACs and iVACs and their relationship to ventilator-associated pneumonia (VAP). We evaluated these using data from a large, multicenter, quality-improvement initiative.**
Methods: **We retrospectively applied definitions for VAC and iVAC to data from a prospective time series study in which VAP clinical practice guidelines were implemented in 11 North American ICUs. Each ICU enrolled 30 consecutive patients mechanically ventilated > 48 h during each of four study periods. Data on clinical outcomes and concordance with prevention recommendations were collected. VAC, iVAC, and VAP rates over time, the agreement (κ statistic) between definitions, associated morbidity/mortality, and independent risk factors for each were determined.**
Results: **Of 1,320 patients, 139 (10.5%) developed a VAC, 65 (4.9%) developed an iVAC, and 148 (11.2%) developed VAP. The agreement between VAP and VAC was 0.18, and between VAP and iVAC it was 0.19. Patients who developed a VAC or iVAC had significantly more ventilator days, hospital days, and antibiotic days and higher hospital mortality than patients who had neither of these conditions. Increased concordance with VAP prevention guidelines during the study was associated with decreased VAP and VAC rates but no change in iVAC rates.**
Conclusions: **VACs and iVACs are associated with significant morbidity and mortality. Although the agreement between VAC, iVAC, and VAP is poor, a higher adoption of measures to prevent VAP was associated with lower VAP and VAC rates.** ***CHEST 2013; 144(5):1453–1460***

Abbreviations: APACHE = Acute Physiologic and Chronic Health Evaluation; iVAC = infection-related ventilator-associated complication; LOS = length of stay; SAT = spontaneous awakening trial; SBT = spontaneous breathing trial; SOFA = Sequential Organ Failure Assessment; VAC = ventilator-associated condition; VAP = ventilator-associated pneumonia

Ventilator associated pneumonia (VAP) remains an important cause of morbidity, mortality, and increased health-care costs in patients who are mechanically ventilated.[1,2] Because VAP is a nosocomially acquired infection, it is regarded as an important patient safety measure, and there have been numerous efforts to promote its prevention.[3,4] Reported VAP rates have been falling, and surveillance data in the United States up to 2010 reported incidences ranging from zero to six cases per 1,000 ventilator-days.[5] However, there is concern that reported rates are variable depending on the personnel who collect the data, the intensity of surveillance, and interpretation of clinical or laboratory data.[6,7] Further, it is recognized

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that surveillance of VAP may systematically underestimate its occurrence and that true rates may be much higher.[8,9] Particularly problematic is that VAP rates as reported from surveillance initiatives, where there

may be variability and difficulty applying current definitions, may not correlate with patient-centered outcomes.[10]

Moreover, because the definition of VAP is nonspecific and does not correlate with histopathologic findings of pneumonia, irrespective of the method of microbiologic confirmation chosen,[11,12] it has been argued that VAP is not an acceptable quality measure in the ICU.[13] The Centers for Disease Control and Prevention have consequently implemented an alternate surveillance paradigm for patients who are mechanically ventilated, moving from pneumonia to broader complications in general. These new surveillance definitions were designed to be more objective and more efficient to collect and are termed ventilator-associated conditions (VACs) and infection-related ventilator-associated complications (iVACs), where iVAC is a subset of VAC.[14]

Evaluative data regarding these new concepts are limited. In initial studies, VAC was found to correlate with clinical outcomes and require less time than VAP for its determination.[15] Further, the objective measures of respiratory deterioration as measured by sustained increases in ventilator settings, such as those quantified in VAC, correlate with increased length of stay (LOS) and hospital mortality.[16]

Because VAP may be a cause of VAC, and given the current focus on VAP rates and implementation of measures to prevent VAP, there is a need for further data regarding the association between VAC, iVAC, and VAP, their clinical outcomes, and their responsiveness to measures that are designed to prevent VAP. We sought to determine these relationships in a large dataset of patients in whom the Canadian VAP guidelines[17,18] were implemented and herein report the results.

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Materials and Methods

This was a retrospective analysis of a prospective, multicenter study that measured the implementation of VAP clinical practice guidelines over 24 months. The study was conducted in six academic and five community, medical/surgical/trauma ICUs (10 Canada, one United States); the average number of beds was 18.5 (SD, 3.7), and 10 had a "closed" administrative structure. The complete description of the ICUs and full study details have been published elsewhere.[19,20] Briefly, in an interrupted time-series design, evidence-based recommendations for the prevention, diagnosis, and treatment of VAP were introduced using a multifaceted intervention. The effect of these interventions on concordance with guideline recommendations and clinical outcomes was then assessed.

Study Enrollment

In each ICU, 30 consecutive adult patients who met the inclusion criteria of age > 16 years and who were mechanically ventilated for > 48 h were enrolled during the baseline and three follow-up data collection periods at 6, 15, and 24 months after the baseline period between June 1, 2007 and December 1, 2009. For patients who met the inclusion criteria, there were no exclusion criteria. A total of 330 patients were enrolled during each data collection period for a total of 1,320 patients. The median number of days required for patient enrollment per site over the four study periods was 55 days (range, 23-140 days).

Data Collection/Outcomes

Patient characteristics collected included age, sex, comorbidities, APACHE (Acute Physiologic and Chronic Health Evaluation) II[21] score at the time of ICU admission, and Sequential Organ Failure Assessment (SOFA)[22] scores at the time of study enrollment (48 h after admission). Clinical outcomes collected included duration of mechanical ventilation, ICU LOS, hospital LOS, antibiotic use, and ICU and hospital mortality.

Research coordinators collected data by direct observation or chart review for concordance with each of the 14 guideline recommendations, including 10 prevention recommendations. Concordance was determined as previously described.[20,23] The percent concordance with each prevention recommendation and in aggregate was calculated for each of the four data collection periods. Although not formally part of the VAP guideline, best practices for discontinuation of mechanical ventilation were encouraged throughout the study, and data regarding spontaneous awakening trials (SATs) and spontaneous breathing trials (SBTs) were collected prospectively.[24]

Clinically suspected VAP was defined as new or progressive and persistent infiltrates on a chest radiograph plus two of the following: abnormal WBC count, presence of fever or hypothermia, purulent sputum, and deterioration in gas exchange (Table 1).[25] Study patients were screened daily for these criteria based on data that were collected for clinical purposes only; the diagnosis was then confirmed by the attending physician and the site principal investigator. In the absence of a reference standard for VAP, all suspected cases were adjudicated centrally by the study coprincipal investigators (J. M., T. S.) to confirm that the clinical course was compatible with VAP, based on culture results, antibiotic response, and lack of other causes to explain the signs and symptoms. Discrepancies were resolved by consensus.