CHEST

A Prospective Evaluation of Ventilator-Associated Conditions and Infection-Related Ventilator-Associated Conditions

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BACKGROUND: The Centers for Disease Control and Prevention has shifted policy away from using ventilator-associated pneumonia (VAP) and toward using ventilator-associated conditions (VACs) as a marker of ICU quality. To date, limited prospective data regarding the incidence of VAC among medical and surgical ICU patients, the ability of VAC criteria to capture patients with VAP, and the potential clinical preventability of VACs are available.

METHODS: This study was a prospective 12-month cohort study (January 2013 to December 2013).

RESULTS: We prospectively surveyed 1,209 patients ventilated for ≥ 2 calendar days. Sixty-seven VACs were identified (5.5%), of which 34 (50.7%) were classified as an infection-related VAC (IVAC) with corresponding rates of 7.0 and 3.6 per 1,000 ventilator days, respectively. The mortality rate of patients having a VAC was significantly greater than that of patients without a VAC (65.7% vs 14.4%, $P < .001$). The most common causes of VACs included IVACs (50.7%), ARDS (16.4%), pulmonary edema (14.9%), and atelectasis (9.0%). Among IVACs, 44.1% were probable VAP and 17.6% were possible VAP. Twenty-five VACs (37.3%) were adjudicated to represent potentially preventable events. Eighty-six episodes of VAP occurred in 84 patients (10.0 of 1,000 ventilator days) during the study period. The sensitivity of the VAC criteria for the detection of VAP was 25.9% (95% CI, 16.7%-34.5%).

CONCLUSIONS: Although relatively uncommon, VACs are associated with greater mortality and morbidity when they occur. Most VACs represent nonpreventable events, and the VAC criteria capture a minority of VAP episodes. CHEST 2015; 147(1):68-81

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ABBREVIATIONS: APRV = airway pressure release ventilation; CDC = Centers for Disease Control and Prevention; IVAC = infection-related ventilator-associated condition; NHSN = National Healthcare Safety Network; PEEP = positive end-expiratory pressure; VAC = ventilator-associated condition; VAP = ventilator-associated pneumonia

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Clinical criteria are known to be nonspecific for the diagnosis of ventilator-associated pneumonia (VAP).[1-10] The Centers for Disease Control and Prevention (CDC)/National Healthcare Safety Network (NHSN) has established a surveillance definition for probable nosocomial pneumonia, including VAP.[11] Unfortunately, these diagnostic criteria were not validated clinically.[12] We previously compared the observed rates of VAP using the CDC/NHSN surveillance method with the CHEST criteria and found that the agreement between the two sets of criteria was poor.[13] Others have also noted that US surveillance rates of VAP are decreasing compared with rates in Europe and Asia, whereas clinical diagnoses of VAP in the United States remain prevalent.[14,15]

Given that VAP surveillance is time consuming and potentially less accurate than clinical/microbiologic criteria and that the use of quantitative lower respiratory tract cultures for the establishment of VAP is not universal, the CDC/NHSN has recently supported efforts aimed at shifting ICU surveillance away from VAP. The CDC/NHSN has focused instead on the occurrence of ventilator-associated "conditions" (VACs) that may circumvent the subjectivity and inaccuracy of the VAP definition, facilitate electronic assessment, and make interfacility comparisons more meaningful.[16] This policy shift toward using VACs as a more objective marker of ICU quality has occurred without robust prospective clinical validation for this purpose and served as the impetus for this study. The goals of this study were to prospectively determine the incidence of VACs among patients in medical and surgical ICUs, to assess the potential preventability of VACs, and to assess the ability of the VAC criteria to identify VAP.

FOR EDITORIAL COMMENT SEE PAGE 5

Materials and Methods

Study Population and Data Collection

The study was conducted in the surgical (36 beds) and medical (29 beds) ICUs of Barnes-Jewish Hospital, a 1,250-bed teaching hospital in St. Louis, Missouri. During a 12-month period (January 2013 to January 2014), ICU patient rosters were screened daily. Patients who were mechanically ventilated for ≥2 calendar days were monitored daily for the development of either a VAC or an infection-related VAC (IVAC). The Washington University Human Research Protection Office approved the protocol (HRPO number 201209071). The following baseline characteristics were recorded at the time of VAC determination: age, sex, race, cause of respiratory failure, comorbid conditions, APACHE (Acute Physiology and Chronic Health Evaluation) II score[17] at ICU admission, and cause of the VAC. Patients with a VAC were followed until hospital discharge or death. Additionally, a determination was made as to whether the VAC represented a potentially preventable event.

Definitions for VAC and IVAC

The definitions used for VAC and IVAC were taken from the recently published update from the CDC.[16] To meet the VAC definition, a patient who was mechanically ventilated must have had at least 2 calendar days of stable or decreasing daily minimum positive end-expiratory pressure (PEEP) or F_{IO_2} followed by at least 2 days of increased daily minimum PEEP or F_{IO_2}, in which the increase in the daily minimum PEEP is ≥3 cm H_2O or the increase in the daily minimum F_{IO_2} is ≥0.20 (or 20 percentage points in oxygen concentration). We modified the CDC VAC definition with clinical judgment based on ventilator mode, and in some cases mortality, in the 2-day window of VAC eligibility. We included potentially salvageable patients achieving the requirement of an increased daily minimum PEEP or F_{IO_2}, but expiring before the 2-calendar day requirement was met. We excluded patients who met the strict interpretation of the CDC VAC criteria but whose deterioration was clinically judged to be consistent with expected impending mortality from their underlying illness. Moreover, although only the F_{IO_2} component of the CDC definition can be applied to patients receiving airway pressure release ventilation (APRV), we included those with a sustained increase in mean airway pressure of ≥3 cm H_2O. IVACs represent the subset of VACs that are potentially infection related, as evidenced by an abnormal WBC count (≥12,000 cells/mm^3 or ≤4,000 cells/mm^3) or temperature (>38°C or <36°C) and a new antimicrobial start. IVACs were defined so as to be likely to capture patients with pulmonary and extrapulmonary infections of sufficient severity to trigger respiratory deterioration. The definitions used for possible and probable VAP were taken from the CDC update.[16]

VAP Definition

The CHEST definition for VAP includes a new or progressive consolidation on chest radiographs plus at least two of the following clinical criteria: fever >38°C, leukocytosis or leukopenia, and purulent secretions.[13] The presence or absence of a new or progressive radiographic infiltrate was based on the interpretation of the chest radiograph by board-certified radiologists who were blinded to the study. The diagnosis of VAP was considered to be microbiologically confirmed if either BAL or protected specimen brush cultures had significant growth using a semiquantitative culture technique (≥10^4 and ≥10^3 colony-forming units/mL, respectively).

Adjudication

For each case, two physician investigators (A. F. B., M. H. K., or N. S.) independently classified each VAC and IVAC as to its preventability. Rater disagreements were resolved by consensus. A preventable VAC was defined as an event resulting in injury to the patient caused by a nonintercepted medical error, either through an act of omission or commission, rather than the underlying illness.[18] A nonpreventable VAC was defined as an unavoidable injury caused by the patient's underlying disease process, associated with appropriate medical care. For example, a pneumothorax associated with central line placement in a patient with severe ARDS was considered preventable, whereas worsening oxygenation in a patient with intraabdominal sepsis despite adequate source control and appropriate antibiotic treatment was considered nonpreventable. Potentially preventable events screened for daily included inappropriate antibiotic therapy (ie, an antibiotic regimen not active against the causative pathogen based on in vitro testing); procedure-related adverse events (eg, pneumothorax, hemorrhage); aspiration of enteral feedings; ventilation with potentially injurious tidal volumes (>6 mL/kg predicted body weight); pulmonary edema from excess IV fluid; effects of excess sedation (eg, atelectasis, aspiration, hypotension); and catheter-associated blood stream infection, wound infection, urinary catheter-associated infection, or probable VAP per CDC criteria.