Frequency and Etiology of Ventilator-Associated Events in the Medical Intensive Care Unit

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Abstract: *Background:* The Centers for Disease Control and Prevention (CDC) has developed new criteria based on a significant deterioration in oxygenation to identify ventilator-associated events (conditions). The aim of this study was to determine how frequently this happened and what caused these conditions. *Methods:* Electronic medical records and x-rays from 281 ventilator episodes in the medical intensive care unit were reviewed to determine the characteristics of patients requiring ventilation and the number of patients meeting the criteria for ventilator-associated conditions (VACs). *Results:* This cohort included 257 patients (55.4% men) who required 281 episodes of mechanical ventilation. The mean Acute Physiology and Chronic Healthy Evaluation II score was 13.5 ± 5.9. The initial mean PaO_2/FiO_2 was 210 ± 110. The median number of ventilator days was 4 (interquartile range: 3–9). The overall mortality was 32.3%. Nineteen patients (11.7% of eligible episodes) met the CDC criteria for a VAC; 6 met FiO_2 criteria (31.6%) and 13 met positive end expiratory pressure criteria (68.4%). Twelve patients (63.2%) had an increased white blood cell count (>12k/μL) during the event. Eleven patients had an increase in temperature (>38°C) during this period. The etiology of these conditions included pneumonia (n = 4), atelectasis (n = 4), congestive heart failure (n = 5), acute respiratory distress syndrome (n = 2), and miscellaneous reasons (n = 4). *Conclusions:* VACs occurred in 11.7% of patients in our medical intensive care unit. The etiology of these events was diverse and did not usually reflect complications. These new CDC criteria for institutional reporting of complications during mechanical ventilation do not necessarily identify complications or provide a good method for comparing outcomes in hospitals.

Key Indexing Terms: Mechanical ventilators; Complications; Pneumonia; Outcomes; Intensive care unit. **[Am J Med Sci 2015;350(6):453–457.]**

Patients requiring mechanical ventilation can develop both intensive care–related and ventilator-associated complications. The best studied of these complications is ventilator-associated pneumonia (VAP). The U.S. Centers for Disease Control and Prevention (CDC) tracks health care–associated infections like VAP under the auspices of its National Healthcare Safety Network (NHSN, formerly known as the National Nosocomial Infection Surveillance System). The NHSN and its predecessor have attempted to track VAP using several protocols, with its last revision known as the PNEU protocol released in 2002.[1] In January 2013, the NHSN instituted a major overhaul of its reporting criteria with the updated ventilator-associated event (VAE) surveillance protocol.[2–4]

Although the PNEU protocol has been widely used, it had a number of limitations. Some items, like changes on x-rays and the development of fever or leukocytosis, are not specific markers for pneumonia. Vague definitions, such as "worsening gas exchange" and "change in character of sputum," make the protocol difficult to apply consistently. Clinical information, such as new onset or worsening cough, dyspnea, and tachypnea, are almost impossible to assess in sedated, ventilated patients. As a result, interobserver variability in making this diagnosis is high.[5] The new NHSN protocol uses the VAE surveillance algorithm to identify patients with possible complications or new medical problems during mechanical ventilation. These criteria require significant and sustained deterioration in gas exchange after at least 2 days of stable or improving gas exchange. Patients who meet these criteria are identified as having a ventilator-associated condition (VAC). From there, key parameters, such as temperature and white blood cell (WBC) count in conjunction with the administration of new antibiotics, are analyzed to determine if the patient has developed an infection-related ventilator-associated complication (IVAC). A more detailed review of the patient's chart is then necessary if a patient meets both the VAC and IVAC criteria to determine if the patient has developed a possible or probable VAP.[3] The last step in the VAE protocol includes information on respiratory secretions and thoracic cultures. An expert panel has suggested that VACs and IVACs are possible candidates for use in public reporting, interfacility comparisons, and for pay-for-performance programs.[3] However, these events do not necessarily represent complications or poor care, and it is unclear whether VACs provide a good method for comparing outcomes in patients requiring mechanical ventilation in different hospitals or provide the basis for quality improvement efforts in hospitals.

The study goals involved a retrospective review of the medical records of patients requiring mechanical ventilation in a medical intensive care unit (MICU) to determine the ease of using the VAE surveillance protocol, the frequency of VACs in patients in a MICU, and the clinical explanations for these events.

METHODS

Data Collection

This is a retrospective study of all adult patients requiring mechanical ventilation in the Medical Intensive Care Unit at University Medical Center in Lubbock, Texas, which is the teaching hospital associated with Texas Tech University Health Sciences Center in Lubbock. All medical records used in this study were available in an electronic format. The hospital billing department provided a list of all patients discharged between December 1, 2012 and April 31, 2013 with a billing code indicating that they received mechanical ventilation in the MICU. There were 276 hospital admissions that met the criteria. All patients aged 90 years or older, any duplicates, and patients who did not receive mechanical ventilation based on thorough review of their charts were subsequently excluded. Individual records were retrieved using the electronic medical records system, and the relevant information was entered into a database of deidentified information in Microsoft Excel. Patients who were extubated and subsequently reintubated were

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Submitted July 17, 2015; accepted in revised form September 4, 2015.

The authors have no financial or other conflicts of interest to disclose.

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analyzed as separate ventilator episodes. Overall, data were collected on 281 ventilator episodes from 257 patients. Information collected included age, gender, admitting diagnosis, respiratory comorbidity, body mass index (BMI; kg/m^2), Acute Physiology and Chronic Healthy Evaluation II score, indication for mechanical ventilation, initial chest x-ray results, initial arterial blood gases, peak and plateau pressure on day 2 of mechanical ventilation at 8 AM, hemoglobin, WBC count, platelet count, creatinine, estimated creatine clearance, duration of ICU stay, and outcome from ICU stay. Other information recorded daily from the electronic record included the lowest FiO_2 and positive end expiratory pressure (PEEP) level recorded by respiratory therapists every 2 hours, the highest or lowest WBC count usually measured daily, and the highest or lowest temperature recorded at least every 4 hours by nurses. ventilator associated conditions were defined by an increase in FiO_2 by 20% or PEEP by 3 cm H_2O, which lasted at least 2 days. The event date is defined as the 1st day of worsening oxygenation, and the window period includes the 2 days before the event date, the 2 event days, and the 2 days after. The 1st 2 days of ventilation were always excluded. For patients with a VAC information on respiratory, blood, and any other cultures available, changes in antibiotics, maximum peak and plateau pressure, respiratory secretions (amount, color, and consistency), and chest x-rays were reviewed to determine the best diagnosis to explain the cause of the event. Sputum recovered by endotracheal suctioning was classified by the worst sputum amount (semiquantitative score: scant [0], moderate [1], large [2]), worst purulent sputum color (semiquantitative score: clear [0], light, tan[1], yellow [2]), worst bloody sputum color (semiquantitative score: clear [0], blood tinged [1], bloody [2]), worst sputum consistency (semiquantitative score: thin [0], moderately thick [1]), and the number of suctions recorded on the initial event day. This information is recorded into the electronic record nurses and respiratory therapists. Final categories for sputum classification included: minimally abnormal sputum (total score, 1–3), moderately abnormal sputum (total score, 4), and markedly abnormal sputum (total score, 5–6). Medical records, including radiograph reports and x-rays, were reviewed by the study investigators to determine the best diagnosis to explain the VAC. This study was approved by the Texas Tech University Health Sciences Center Institutional Review Board.

Data Analysis

Continuous variables were summarized with mean values and SDs or medians and interquartile ranges. Categorical data were summarized with counts and percentages. Comparisons were made with t tests, χ^2 tests, analysis of variance, and ranking tests. $P \leq 0.05$ were considered significant. Statistical analysis was carried out with Microsoft Excel and SPSS.

RESULTS

Our study included 257 patients with 281 episodes of mechanical ventilation. Patient demographics are reported in Table 1. The admitting diagnoses are summarized in Table 2. The initial indications for ventilation at the time of admission included hypoxemia (37%), decreased level of consciousness (18.5%), hypercapnia (16%), cardiac arrest (10%), out of hospital intubation (8.9%), and other (9.5%, chronic ventilation, postsurgery, etc). The initial (admission) chest radiographs showed clear lung fields in 34.5% of all ventilation episodes, infiltrate(s) in 30.6% (11.4% diffuse, 10.7% one focal, 6.4% more than one focal, 2.1% diffuse unilateral infiltrate), pleural effusions in 9.2% (2.1% effusion with diffuse infiltrate and 7.1% effusion without infiltrate), atelectasis in 3.9%, cardiomegaly in 3.6%, and others abnormalities in 18.1%. The mean Acute Physiology and Chronic Healthy Evaluation II score was 13.5 ± 5.9. The mean initial PaO_2/FiO_2 was 210 ± 110, the mean PCO_2 was 45.1 ± 22.8 mm Hg, and the mean pH was 7.3 ± 0.1. The total number of ventilation days was 1644.

Daily FiO_2 and PEEP values were recorded, and VACs were identified using the new 2013 CDC criteria. To meet the CDC VAE surveillance criteria, each episode of ventilation has to last 4 days or longer. After eliminating the short ventilator episodes of fewer than 4 days, 162 eligible ventilator episodes were long enough to meet the CDC criteria. Nineteen episodes (6.7% of all 281 episodes and 11.7% of eligible episodes based on time criteria) met the CDC criteria for a VAC based on deterioration in gas exchange. Thirteen (68.4%) were PEEP

TABLE 1. Demographic characteristic of patients

Variable	Number (N = 257)	Percentage (%)
Age, years		
<50	65	25.3
50–70	119	46.3
>70	73	28.4
Gender		
Male	140	54.5
Female	117	45.5
BMI,[a] kg/m^2		
Underweight (BMI <18.5)	20	7.1
Normal (18.5 ≤BMI <25)	75	26.7
Overweight (25 ≤BMI <30)	74	26.3
Obese (BMI ≥30)	112	39.9

[a] Based on all 281 episodes.
BMI, body mass index.

TABLE 2. Admitting diagnoses[a]

Pneumonia	58
SIRS, sepsis	24
COPD exacerbation	24
Cardiac arrest	20
Overdose	19
CVA	19
CHF	16
Respiratory failure	15
GI bleed	8
Asthma exacerbation	7
Acute coronary syndrome	6
Surgical	6
Cancer	4
DKA	4
AKI	3
PE	2
Miscellaneous	46

[a] All episodes of mechanical ventilation.
AKI, acute kidney injury; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CVA, cerebral vascular accident; DKA, diabetic ketoacidosis; GI, gastrointestinal; PE, pulmonary emboli; SIRS, systemic inflammatory response syndrome.