A ventilator-associated event in an intensive care unit patient with multiple comorbidities and prolonged mechanical ventilation

Çoklu komorbiditesi ve uzamış mekanik ventilasyonlu olan bir yoğun bakım hastasında ventilatörle ilişkili olay

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Abstract

The old Centers for Disease Control and Prevention (CDC) criteria for ventilator-associated pneumonia included a new or a progressive and persistent pulmonary infiltrate, signs of inflammation based on changes in temperature or white blood cell counts, and at least two the following clinical signs (purulent sputum, increased respiratory symptoms, rales or bronchial breath sounds, and/or deteriorating gas exchange). These criteria are difficult to use and resulted in significant variation in reporting rates by hospitals. The CDC recently introduced new criteria for ventilator-associated events. These criteria require a significant deterioration in gas exchange based on an increase in FiO2 (by 20%) and/or the PEEP level (by 3 cmH_2O). These new criteria do not consistently identify ventilator-associated pneumonia and have other causes, such as the progression of the primary underlying disease or the development of pulmonary edema. We discuss a patient managed in our medical intensive care unit to illustrate the difficulties in identifying patients with ventilator-associated pneumonia and using the new CDC criteria for ventilator-associated events.

Keywords: Artificial; Centers for Disease Control and Prevention; complications; mechanical; pneumonia; respiration; ventilator-associated; ventilators

Özet

Ventilatörle ilişkili pnömoni için eski Centers for Disease Control and Prevention (CDC) kriterleri, yeni veya ilerleyen ve kalıcı pulmonerin filtratı, beyaz küre sayısında veya sıcaklıktaki değişime dayalı inflamasyon işaretleri ve aşağıdaki klinik işaretlerin (pürülan balgam, artmış respiratuvar semptomlar, raller veya bronşiyal nefes sesleri, ve/veya kötüleşen gaz değişimi) en az ikisini içerir. Bu kriterlerin kullanımı zordur ve hastanelerin bildirim oranlarında önemli farklılıklara sebebiyet vermiştir. CDC, son zamanlarda ventilasyonla ilişkili olaylar için yeni kriterler yayınlamıştır. Bu kriterler gaz değişiminde FiO_2 (%20 değişim) ve/veya PEEP seviyesinde (3 cmH_2O değişim) gibi ciddi bozulmayı gerektirmektedir. Bu yeni kriterler, ventilatörle ilişkili pnömoniyi ve primer esas hastalığın ilerlemesi veya pulmoner ödem gelişimi gibi diğer sebepleri tam olarak tanımlamamaktadır. Ventilatörle ilişkili pnömonisi olan hastalardaki zorlukları ve CDC'nin ventilatörle ilişkili olaylar için yeni kriterlerini açıklamak amacıyla bizim tıbbi yoğun bakım ünitemizde tedavi edilen bir hastayı tartışıyoruz.

Anahtar kelimeler: Yapay; Centers for Disease Control and Prevention; komplikasyonlar; mekanik; pnömoni; solunum; ventilatörle ilişkili, ventilatörler

Introduction

Patients requiring mechanical ventilation can have multiple complications during this phase of their medical care (1,2). These complications include laryngeal and tracheal trauma, barotrauma, oxygen toxicity, aspiration, and ventilator-associated pneumonia. Ventilator-associated pneumonia is considered a hospital-acquired condition and is an important cause of morbidity, increased lengths of stay, and higher hospital costs. The diagnostic criteria for this condition are difficult to apply, and the frequency of ventilator-associated pneumonia varies significantly among hospitals. The Centers for Disease Control and Prevention (CDC, Atlanta, Georgia, USA) has developed new criteria for ventilator-associated conditions, now using an algorithm which starts with a significant change in oxygen.

Case Summary

A 62-year-old obese non-smoking woman with a history of restrictive lung disease, pulmonary embolism, OSA on oxygen 4 l/minute NC at home, CKD stage III, and HTN presented with chest discomfort for one week. The pain (rated 8/10) was left sided, dull in nature, and non-radiating. She also had worsening shortness of breath for a few days and had contact with a relative with pharyngitis. Physical examination revealed an obese woman with a BMI>40 kg/m^2, temperature 101.6°F, BP 153/79 mmHg, HR 78 beats per minute, and RR 18 breaths

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Received: 01.04.2014 **Accepted:** 28.04.2014
ISSN 2148-3132 (print) ISSN 2148-2926 (online)
www.gaziantepmedicaljournal.com
DOI: 10.5455/GMJ-30-156516

per minute on O_2 at 4 l/minute by NC. Her lungs were clear to auscultation, respirations non-labored, and breath sounds equal. She had bilateral lower leg edema.

Laboratory studies: white blood count $10.2x10^9$/l, creatinine 1.3 mg/dl (estimated GFR-42 ml/minute /1.73m^2), and urinalysis with 15-20WBC/LPF and positive leukocyte esterase. Chest X-ray showed cardiomegaly, prominent upper zone vessels, and faint alveolar infiltrates at the bases. ECG showed no acute ST/T wave changes, and cardiac enzymes were negative. Arterial blood gases revealed a pH 7.4, $PaCO_2$ 53 mmHg, and PaO_2 66 mmHg on a FiO_2 of 36%.

The patient was initially placed on CPAP and started on an acute coronary syndrome (ACS) protocol and ciprofloxacin for asymptomatic pyuria. A dobutamine stress echo showed no evidence of ischemia, and the ACS protocol was discontinued. The patient's respiratory symptoms increased, and she required a venti-mask with 50% FiO_2. The next day she was drowsy with a pH 7.1, $PaCO_2$ 107 mmHg, and PaO_2 115 mmHg and was transferred to intensive care for mechanical ventilation (Figure 1).

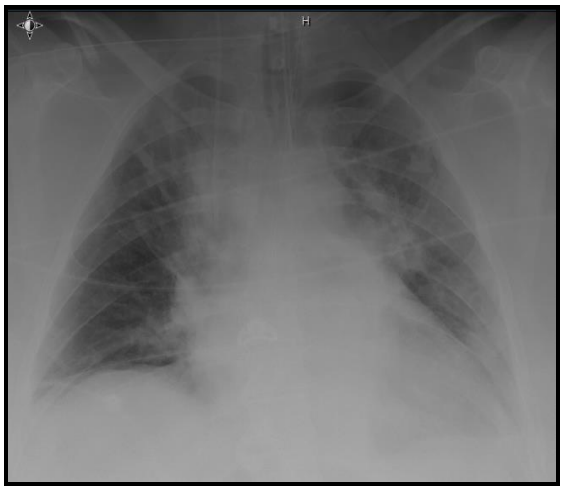

Figure 1. Portable AP film after the initial intubation with bilateral patchy infiltrates, cardiomegaly and small lung volumes.

The patient's respiratory status stabilized, but she required relatively high FiO_2s (50%-60%) despite treatment with diuretics and broad spectrum antibiotics. Follow up chest X-rays showed increasing bilateral patchy infiltrates more prominent on the right side. Blood and urine cultures were negative. Her sputum culture grew oxacillin resistant *Staphylococcus aureus*. The patient was extubated on day eight (FiO_2 45% and PEEP 5) but had to be reintubated by the anesthesiology service that day for hypoxemia. Her respiratory status and gas exchange deteriorated, she required a higher PEEP (10 cmH_2O), and her chest x-ray revealed bilateral patchy infiltrates, increased on the left, and a small right apical pneumothorax.

Discussion

Ventilator-associated complications can occur at any time during episodes of respiratory failure requiring mechanical ventilation (1). These complications can involve both the upper airway and the lung parenchyma. Upper airway trauma can occur during intubation and during prolonged use of cuffed endotracheal tubes. Barotrauma can cause pneumothorax and/or pneumomediastinum with important consequences. High alveolar pressures can cause over distention of regional alveolar units with lung stretching (volutrauma), cyclical closure and opening of collapsed lung regions can cause trauma (atectrauma), and high concentrations of oxygen can cause oxygen toxicity. These events release inflammatory mediators which amplify lung injury and can have systemic effects, such as multiorgan failure. These patients are also at risk for chemical pneumonitis secondary to aspiration of gastric secretions and ventilator-associated pneumonia. The incidence of ventilator-associated pneumonia has been difficult to establish. A meta-analysis published in 2002 reported that 8-28% of patients on ventilators developed ventilator-associated pneumonia (4). A more recent study in North American hospitals calculated an incidence rate of 5.7% to 9.7% (5). A report published in 2011 found an incidence rate of 0.04-4.9 ventilator-associated pneumonia cases per 1.000 ventilator days (6). Ventilator-associated pneumonia significantly increases the length of hospitalization and hospital costs (7). These pneumonias are frequently associated with drug-resistant bacteria and may represent a reservoir for these bacteria in hospitals. A major uncertainty in all studies on ventilator-associated pneumonia involves the difficulty in establishing an exact diagnosis. Some hospitals potentially underreport this condition because of the vague standards used for diagnosis and the frequent presence of alternative explanations for pulmonary infiltrates, leukocytosis, and fever.

In 2013, the CDC issued new guidelines for the identification and evaluation of patients with ventilator-associated complications (2,3). These guidelines replace prior guidelines used for the identification and reporting of ventilator-associated pneumonia and require a significant deterioration in gas exchange identified either by an increase in FiO_2 by 20% for two consecutive days or by an increase in PEEP by 3 cmH_2O for two consecutive days. This definition requires at least two days of mechanical ventilation with stable or improving gas exchange and then two days of definite deterioration in gas exchange. If this change in gas exchange occurs, the patient has a ventilator-associated condition. The next step is to determine whether or not the patient has had an infection-related, ventilator-associated complication defined by a temperature (<36°C or> 38°C) or white blood counts (≤4.000/µl or ≥12.000/µl) and the addition of a new antibiotic(s) for at least four calendar days. Patients who meet

this definition are evaluated for a possible ventilator-associated pneumonia (based on purulent secretions on a Gram stain **or** positive respiratory culture) or a probable ventilator-associated pneumonia (based on purulent secretions **and** a positive quantitative culture or other definitive evidence of a pulmonary infection).

Former CDC criteria for ventilator-associated pneumonia required a new or progressive and persistent infiltrate, signs of inflammation (temperature [<36°C or >38°C], or a WBC >12.000/µl, or altered mental status if ≥70 years of age) and at least two of the following: purulent sputum, increased respiratory symptoms, rales or bronchial breath sounds, and deteriorating gas exchange (8). These criteria are not specific for pneumonia, and the symptom and physical examination criteria are difficult to use in intubated, sedated patients. Consequently, reporting rates varied significantly from hospital to hospital. Safdar and coworkers (8) compared the CDC surveillance criteria with the clinical pulmonary infection score (CPIS) in 73 patients in a tertiary care hospital. They found good agreement between the CDC criteria and the CPIS; the CPIS had a sensitivity of 0.89 and a specificity of 0.91. The original CPIS requires a tracheal aspirate culture and is not immediately useful. Tan and colleagues (9) compared the CPIS to clinical criteria (a new infiltrate and at least two additional parameters, including leukocytosis, leukopenia, fever, hypothermia, or purulent secretions) and found that the CPIS had a sensitivity of 0.35 on the first day of evaluation and 0.78 on the third day of evaluation. Zilberberg and Shorr (10) reviewed the use of the CPIS as a diagnostic test in ventilator-associated pneumonia and concluded that it had limited sensitivity and specificity and a high inter-observer variability. These studies suggest that clinical evaluation provides a basis for good patient care, but that these criteria may not systematically provide uniform information for reporting infection rates to external agencies.

Difficulties with the CDC definition for ventilator-associated pneumonia led to this new approach for identifying ventilator-associated complications based on a significant deterioration in gas exchange. Klompas and co-workers (11) tested in the utility of objective definitions for ventilator-associated pneumonia in over 8.000 patients requiring over 50.000 ventilator days. This study demonstrated that the incidence of ventilator-associated pneumonia ranged from 26.3 events per 1.000 ventilator days with the least restrictive definition(purulent pulmonary secretions alone) to 0.2 events per 1000 days with the most restrictive definition (the highest threshold increase in ventilator settings plus abnormal temperature/WBC plus purulent secretions plus pulmonary pathogens on culture). These authors suggested that objective criteria provide an efficient method to identify complications and compare outcomes within and between institutions. A second multicenter study demonstrated that an increase in PEEP≥2.5 cmH_2O or in FiO_2 ≥15% is associated with an increased number of ventilator days, an increased number of hospital days, and increased mortality even after adjustment for severity using APACHE 2 scores (12). These ventilator-associated complications were attributed to pneumonia, pulmonary edema, acute respiratory distress, and atelectasis (12,13). Consequently, this definition identifies severe complications which developed after the institution of mechanical ventilation and a period of stability or improvement, and it identifies several different types of complications. Some of these complications represent the natural progression of underlying disease, and some represent true complications which might be avoided. However, this change in clinical status based on gas exchange indicates the patient's prognosis is worse, and these patients need careful reassessment. This definition ignores complications which occur during the initial phase of ventilation when the patient is stabilizing and/or improving. It also correlates poorly with the presence of ventilator-associated pneumonia based on radiographic and clinical criteria and will not identify patients with small infiltrates (14).

Our patient had a ventilator-associated event defined by an increase in PEEP. At that time she had a WBC $11x10^9$/l and a temperature 37.9°C. Her chest x-ray showed an increased infiltrate in the left mid lung and a small right apical pneumothorax. She required increased PEEP for five days and an increased FiO_2 for one day. Her impaired gas exchange was probably explained by refractory atelectasis, and the PEEP was increased to recruit dependent lung zones. The patient remained in respiratory failure and intubated for 25 days, had a tracheostomy, and was transferred on a ventilator with 7 cmH_2O PEEP and50% FiO_2 to a long term acute care facility.

Teaching points

1. The new CDC criteria require a significant deterioration in gas exchange to qualify for a ventilator-associated complication.
2. The criteria are not specific for pneumonia and may not detect small infiltrates that do not cause major changes in oxygenation.
3. Changes in oxygenation have several potential explanations, including infection, atelectasis, pulmonary edema, pulmonary hemorrhage, and pulmonary emboli.
4. Changes in FiO_2 or PEEP to this extent likely identify patients with an important complication or progression of the underlying disease. The prognosis is worse in these patients.
5. ICUs should probably consider the development of local criteria to monitor patient outcomes and complications during mechanical ventilation in addition to reporting ventilator-associated events.

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How to cite:

Edriss H, Whiting J, Nugent K. A ventilator-associated event in an intensive care unit patient with multiple comorbidities and prolonged mechanical ventilation. Gaziantep Med J 2014;20(3):277-280.