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The Impact of the Centers for Disease Control and Prevention New Surveillance Definitions of Ventilator-Associated Event on Our Clinical Practice

Hastalık Kontrol ve Önleme Merkezlerinin Ventilatörle İlişkili Olaylara İlişkin Yeni Sürveyans Tanımlarının Klinik Uygulamalarımız Üzerindeki Etkisi

Elif Hakko[1], Tülin Tünel[2], İpek Değer Karaman[3], Melda Özdamar[4]

[1] Anadolu Medical Center, Department of Infectious Disease, Kocaeli, Türkiye

[2] Anadolu Medical Center, Department of Intensive Care Unit, Kocaeli, Türkiye

[3] Anadolu Medical Center, Department of Infection Control, Kocaeli, Türkiye

[4] Anadolu Medical Center, Department of Microbiology, Kocaeli, Türkiye

ORCID ID: Elif Hakko: https://orcid.org/0009-0006-4067-4589, Tülin Tünel: https://orcid.org/0000-0001-9121-8598
İpek Değer Karaman: https://orcid.org/ 0009-0000-3070-4269, Melda Özdamar: https://orcid.org/0000-0003-3532-9255

***Sorumlu Yazar / Corresponding Author:** Elif Hakko, **e-posta / e-mail:** ehakko@yahoo.com

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Abstract

Amaç Ventilatör ilişkili pnömoni (VİP) sürveyansı subjektif, net olmayan, zaman alıcı ve sonuçları tahmin ettiremeyen bir yöntemdi. Amerikan Hastalık Kontrol ve Koruma Merkezi (CDC) 2013 yılında Ventilatörle ilişkili pnömoni yerine Ventilatör ilişkili olay (VİO) tanımlarına kullanmayı önerdi. Bu nedenle, biz de bu yeni sürveyans algoritmasını VİP ve VİO yöntemlerinin sonuçlarını kıyaslayarak gözden geçirdik.

Gereç ve Yöntem Hastanemizin 13 yataklı medikal ve cerrahi yoğun bakımında ünitesinde (YBÜ) mekanik ventilasyona bağlanmış hastaları değerlendirdik. Retrospektif olarak, 2018-2019 yılları arasında VİP tanısı almış hasta ve 2022-2023 yılları arasında 11 VİO tanısı almış hasta incelendi. Yeni tanımların mekanik ventilasyon süresi, antibiyotik kullanım süresi, YBÜ kalış süresi gibi klinik süreçlere etkisi enfeksiyöz durumları incelenerek gözden geçirildi.

Bulgular Her iki VİP ve VİO grubunda demografik ve sayısal verinin istatiksel olarak benzer olduğu görüldü ($p<0.5$). Hastaların klinik süreçleri incelendiğinde, 2004 CDC kriterlerine göre tanımlanan dokuz VİP hastanın sadece ikisi ve yeni kriterlerine göre tanımlanan 3 olası VİP (OVİP) hastanın biri pnömoni nedeniyle kaybedilmiştir. OVİP grubunda pnömoni en önemli ölüm nedenidir.

Sonuç Bu çalışmada, OVİP olarak tanımlanmış hastalarda pnömoni nedeniyle ölüm oranın daha yüksek olması durumu, yeni kriterlerin sadece pnömoniyi değil aynı zamanda kesin pnömoni tanısı koymayı zorlaştıran, mekanik ventilasyona bağlı komplikasyonları saptayabileceğini ortaya çıkarmıştır.

Anahtar Kelimeler Mekanik ventilasyon, ventilatör-ilişkili olay, ventilatör- ilişkili pnömoni

Özet

Aim *Surveillance of ventilator-associated pneumonia is subjective, inaccurate, time-consuming, and does not predict outcomes. The Centers for Disease Control and Prevention (CDC) recommended the use of ventilator-associated event (VAE) definitions instead of ventilator-associated pneumonia (VAP) in 2013. Therefore, we evaluated this novel surveillance algorithm by comparing the results of our VAP and VAE methods.*

Material and Method *We evaluated mechanically ventilated adult medical and surgical patients in our 13-bed intensive care unit (ICU). Nine patients diagnosed with VAP in 2018-2019 and 11 patients diagnosed with VAE in 2022-2024 were retrospectively evaluated. The impact of the new definitions on clinical processes such as days on the mechanical ventilator, duration of antibiotic use, ICU stay in determining infectious status was monitored.*

Results *Statistical analysis revealed that demographic and numeric data were similar in both VAP and VAE diagnosis groups ($p<0.5$). When the clinical course of the patients was examined, it was found that only two of the nine VAP patients diagnosed according to the 2004 CDC criteria and one of the three probable VAP (PVAP) patients diagnosed according to the new criteria died of pneumonia. Pneumonia was the main reason of mortality in PVAP group.*

Conclusion *The fact that mortality due to pneumonia was higher in those diagnosed with PVAP suggests that the new criteria may screen not only for pneumonia but also for complications that may confound accurate pneumonia diagnosis.*

Keywords *Mechanical ventilation, ventilator-associated event, ventilator-asssociated pneumonia*

INTRODUCTION

Even though non-invasive mechanical ventilation and high-pressure nasal oxygen therapy have been more commonly used in intensive care units in recent years, invasive mechanical ventilation is still the predominant approach to the management of critical care patients.[1] Several conditions such as pneumonia, barotrauma, fluid overload, pulmonary embolism, pneumothorax and atelectasis are mostly seen in mechanically ventilated patients.[2] Ventilator-associated pneumonia (VAP) has been the primary quality indicator in inter-institutional comparisons.[3,4] VAP diagnosis included radiologic, systemic, and pulmonary criteria, with optional inclusion of pulmonary secretion culture positivity. Positive culture of pulmonary secretions was an optional inclusion.[5] However, this definition was considered time consuming and subjective, therefore in 2013 the CDC endorsed the use of ventilator-associated event (VAE) definitions as a replacement for VAP.[6-8] While VAE surveillance is more complex and requires trained human resources, even though it has been used in U.S. hospitals for nearly 10 years, it has not been widely adopted worldwide.

VAE provides a specific definition for complications occurring after 48 hours of mechanical ventilation, with three sub-conditions defined: Ventilator-associated condition (VAC), infection-related ventilator-associated complication (IVAC), ventilator-associated (VAE), and possible ventilator-associated pneumonia (PVAP). The VAE algorithm was implemented at Anadolu Medical Center in 2022. This study focuses on the impact of the new definitions on clinical processes such as ventilator days, antibiotic use, and length of stay ICU. Specifically, it evaluates the impact of these new definitions on determining infectious status compared to previous VAP diagnoses. This review provides valuable insights into the practical implications of these new definitions and promotes further interest and controversy in the field.

MATERIALS and METHODS

Patients who fulfilled the criteria for VAP and VAE and were supported by mechanical ventilation in the 13-bed general intensive care unit of Anadolu Medical Center were retrospectively evaluated. All nine patients had VAP in 2018-2019; VAE was recognized in 11 patients between 2022-2023. The demographic information of the patients is summarized in Table 1. CDC criteria published in 2004 were used to diagnose VAP. The criteria identified patients with ≥105 cfu/mL growth in deep tracheal aspirate, quantitative culture, fever ≥38.5°C or ≤35°C, and abnormal leukocyte count (≥10,000 or ≤5,000/mm3) as VAP.[9] VAE algorithm's three-step VAC, IVAC, and PVAC criteria were used.[8,10,11] Patients diagnosed with VAP during the COVID-19 pandemic period were excluded from the study.

Patients' age, gender, primary diagnosis, diagnosis of admission to intensive care unit, number of days of intensive care stay, number of ventilator days; On the day of VAP / VAE diagnosis, APACHE II, Carlson Co-Morbidity index was calculated and presented as mean value (MV) + standard deviation (SD).[12,13] Differences between VAE and VAP groups were analyzed with the Mann-Whitney U test and $p<0.05$ was considered significant. Statistical analysis was performed with IBM SPSS Statistics 22.0 package program (IBM Corporation, Armonk, NY, USA).

Since the study was retrospective and observational there was no need to take informed consent from the patients and we did not mention the names and pictures of patients.

RESULTS

In this single centre retrospective study, the comparison of demographic and clinical features of our ICU patients for VAP and novel VAE criteria is summarized in Table 1. In the results of data analysis; the mean age of patients diagnosed with VAP was 57.9±21 years, while the mean age of patients diagnosed with VAE was 43±18 years. There was no statistically significant difference in age between patients diagnosed with VAP and VAE ($p=0.412$).

The gender distribution of the two groups was similar and there was no significant difference between the APACHE II score and the Carlson Co-Morbidity Index. The length of stay in the ICU, the duration of the ventilator days, the number of days with a diagnosis of VAP or VAE after admission to the ICU, and the number of days with antibiotic use after diagnosis were also similar between the two groups.

Table 1. Demographic Features and Clinical Outcomes of Tte Groups

	VAP	VAE	p
Age	57.9 + 2	43 + 2	0,4
Gender (F/M)	4/5	4/7	
Apache II (MV + SD)	27.6+5	28+11	0.4
Carlson Co-morbidity index (MV + SD)	5.7+ 2	6.5+ 2	0.3
VAP/VAE definition day (MV + SD)	10.8 + 6	10+9	0.3
Ventilation days (MV + SD)	29.4 + 2	20.2+11	0.2
Length of ICU (MV + SD)	32 + 26	21+11	0.2
Antibiotic usage days (MV + SD)	9 + 2	12 + 3	0.8

Differences between two groups were analyzed with the Mann-Whitney U test and $p<0.5$ was considered significant. MV: Mean Value, SD: Standard Deviation
Abbreviations: F; female, M; Male, VAP; Ventilator-associated pneumonia, VAE; Ventilator-associated event, ICU; Intensive Care Unit

Surveillance data of patients in our hospital's 13-bed adult medical-surgical intensive care unit for 2018-2019 and 2022-2023 is shown in Table 2. VAP rate was found to be similar according to the years and diagnostic criteria.

Table 2. Surveillance Data

Definition	Year	Number	Device use days	Device use rate
VAP	2018	4	1230	0.40
VAP	2019	5	1418	0.45
VAE	2022	14	1880	0.55
VAE	2023	6	1593	0.57

Of the nine patients diagnosed with VAP, two were admitted to the intensive care unit due to cardiogenic shock, and seven due to organ dysfunctions related to underlying malignancy. Of the eleven patients diagnosed with VAE, only one patient was admitted to the intensive care unit due to trauma, while the remaining ten patients were admitted due to organ dysfunctions secondary to malignancy. Two of the nine patients diagnosed with VAP and one of the eleven patients diagnosed with VAE survived. Two patients diagnosed with VAP exhibited definitive evidence of pneumonia. Upon evaluation according to VAE criteria, pneumonia was identified in a single patient with PVAP.
In respiratory tract samples, Pseudomonas aeruginosa was identified in seven out of nine patients diagnosed with VAP, methicillin-resistant Staphylococcus aureus (MRSA) in one patient, and Klebsiella pneumoniae (which produces carbapenemases) in one patient. Following the application of VAP criteria for surveillance, only one out of eight patients identified with VAP exhibited growth of Stenotrophomonas maltophilia. In contrast, all two patients evaluated with PVAP criteria demonstrated growth of Stenotrophomonas maltophilia. Furthermore, only one out of 11 patients diagnosed with VAP survived. Pneumonia was observed in two patients diagnosed with VAP and one patient diagnosed with PVAP (Table 3).

Table 3. Clinical Features of VAP and VAE Patients

	Primary Diagnosis	Culture	Outcome	Cause of death
VAP	Brain injury	*P.aeruginosa*	Alive	
	Trauma	MRSA	Alive	
	AML	*S.maltophilia*	Ex	Sepsis
	MVR	*K. pneumoniae*	Ex	Cardiogenic shock
	NHL	*P.aeruginosa*	Ex	Pneumonia
	Pancreas ca	*P.aeruginosa*	Ex	Malignancy
	Pancreas ca	*P.aeruginosa*	Ex	Sepsis

	CVA+ Lung ca	*P.aeruginosa*	Ex	Pneumonia
	MDS	*P.aeruginosa*	Ex	Sepsis
VAE	HL	*No growth*	Ex	Sepsis
	NHL	*Cryseobacterium spp.*	Ex	Malignancy
	Lung ca	*S.maltophilia*	Ex	Sepsis
	Endometrium ca	*C.albicans*	Ex	Malaria
	Breast ca	*B.cepacia*	Ex	Sepsis
	Lung ca	*S.maltophilia*	Ex	Sepsis
	Gunshot wound	No growth	Alive	
	Lung ca	No growth	Ex	Malignancy
	MM	No growth	Ex	Pneumonia
	Lung ca	No growth	Ex	Sepsis
	HL	*S.maltophilia*	Ex	Sepsis

Abbreviations: AML: Acute Myeloid Leukemia; NHL: Non-Hodgkin Lymphoma; CVA: Cerebrovascular accident; HL: Hodgkin Lymphoma; MVR: Mitral Valve Replacement; MM: Multiple Myeloma EX: Exitus M: Male, F: Female. APACHE II (Acute Physiology and Chronic Health Evaluation II); ca:cancer, *P.aeruginosa: Pseudomonas aeruginosa*, MRSA: Methicillin-resistance *Staphylococcus aureus; S.maltophilia: Sthenotrophomonas maltophilia*; *C.albicans: Candida albicans; B.cepacia: Burkholderia cepacia; K. pneumoniae: Klebsiella pneumoniae*

DISCUSSION

In this retrospective single-centre study, we aimed to compare the complication definitions and clinical outcomes of the new objective VAE criteria in mechanical ventilation processes with the traditional VAP criteria. Table 1 shows no significant differences in demographic data, length of ICU, ventilation days, severity scores, and clinical outcomes when comparing the periods in which the old and new definitions were used ($p>0.05$). Upon examining the clinical outcomes, it was noted that two out of nine patients diagnosed with VAP and one out of three patients diagnosed with PVAP had reported as pneumonia. This highlights the significance of accurate and timely diagnosis, as it can substantially impact patient outcomes. As shown in Table 2; the rates of device usage were similar in both study periods. While VAP rate was 3.3/1000, the PVAP rate, according to VAE definitions, was found to be 1.5/1000. Although this decrease rate was not statistically significant, this may be due to our low numbers and the need for further research with larger sample sizes as shown by Rawat et al. after switching to VAE criteria, IVAC and PVAP rates decreased by nearly half compared to VAP.[14] This could encourage us for further researches which are crucial to fully understand the potential of VAE criteria.
Bouadma et al. found that only 14.5% of patients with comprehensive VAC diagnosis had pneumonia, highlighting the need to consider other nosocomial infections, pneumothorax, atelectasis, pulmonary embolism, and similar conditions.[15]

Therefore, adding objective criteria to VAE definitions has brought about a focus on infection control and improved antibiotic use by reliably finding infectious conditions. Hassan et al. showed that VAE prevention packages reduced IVAC and PVAP rates but were not associated with decreased VAE rates.[16] Some other interventions, such as head-of-bed elevation, daily spontaneous awakening and breathing trials and the use of slight sedatives, are associated with a decrease in the incidence of VAE.[17] Detecting complications related to mechanical ventilation using new definitions is expected to improve the quality of care and outcomes for patients on mechanical ventilation. Therefore, other new precaution packages should be brought to the agenda in addition to known VAP prevention strategies.

We also thought that with the use of the VAP algorithm in our hospital, more accurate pneumonia diagnoses were made. When the patient documents and clinical processes were examined, it was seen that only two of the nine patients diagnosed with VAP according to the CDC 2004 criteria and one of the three patients diagnosed with PVAP according to the new criteria died due to pneumonia. The fact that the mortality rate due to pneumonia is higher in those diagnosed with PVAP gives a clue that the correct diagnosis of pneumonia is made and that we evaluate the non-infectious causes of those we define as VAP as pneu-

monia. Melson et al. showed in their study that although ventilator associated complications caused a similar extension of mechanical ventilation and intensive care stay, the mortality rate was higher in VAP cases.[18] Therefore, it was thought that making a clear distinction between complications and pneumonia would reduce antibiotic use. It was seen that there was no decrease in antibiotic use in our patients but when the clinical documents of the patients were examined retrospectively, it was determined that antibiotics had to be used for other reasons, such as pneumothorax, neutropenic fever, intra-abdominal sepsis, and septicaemia.

VAP definitions have also enabled the detection of mechanical ventilation complications. In addition to infection, atelectasis, pleural effusion, acute pulmonary oedema, ARDS, pulmonary embolism, and pneumothorax are frequently encountered in patients using mechanical ventilation.[2] It is known that bundle packages used for VAP prevention do not prevent complications.[19,20] Therefore, the need for accurate clinical quality measurements, not solely based on pneumonia, is urgent. More meaningful results will be obtained regarding quality healthcare by preventing other complications.

Ventilator-associated pneumonia is based on infiltrates on chest X-rays, leading to unnecessary prolonged antibiotic use for patients. It is known that chest X-rays taken in the ICU have difficulty distinguishing between infection and non-infectious causes and are not specific for infection. Interpreting radiographs is challenging; many films are portable and of poor quality, and pre-existing pulmonary disease can mimic pneumonia.[21] A weak correlation was found between the clinical diagnosis of VAP and histologically proven infection.[22] In a post-mortem histopathological study, Balthazar et al. detected pneumonia in only 20% of their patients with a clinical VAP diagnosis in lung biopsy samples. They found conditions such as ARDS, interstitial fibrosis, diffuse alveolar damage, diffuse alveolar oedema, and pulmonary embolism, among others.[23]

The complexity and unreliability of VAP surveillance have shown that more than healthcare-associated infection rates are needed for intra-institutional and inter-institutional comparisons. VAE definitions, with their more standardized surveillance reports and potential for automation in quality programs, could significantly improve the accuracy and efficiency of ventilator-associated infection surveillance.[24]

Our study is primarily helpful in comparing the new algorithm with the previous one in clinical practice and identifying areas for improvement. However, it is essential to note that our most significant limitations were the short study period and the small number of patients. These limitations may have affected our findings' generalizability and our conclusions.

VAE definitions demonstrate promising potential in identifying complications associated with mechanical ventilation suggesting a promising future for enhancing patient outcomes and infection control. With increased confidence in the new definitions, we anticipate a positive impact on patient care. This study will contribute to the more accurate use of the VAE algorithm in the coming years, as we are still in the testing, understanding, and adaptation phase.

Ethics Approval

This study was reviewed and approved by Ethics Committee of Anadolu Medical Center (ASM-EK ASM EK ASM-MM-24/407).

Peer-review

Externally and internally peer-reviewed.

Authorship Contributions

Concept: E.H., T.T., Design: E.H., T.T., Data Collection or Processing: T.T., I.K., M.O., Analysis or Interpretation: T.T., E.H., Literatüre Search: E.H., T.T., Writing: E.H., T.T.

Conflict of Interest

No conflict of interest was declared by the authors.

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