

Factors Relating To Ventilator-Associated Event (VAE)

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ABSTRACT

Mechanical ventilation is oxygen therapy that's effective in saving the lives of critical patients in the intensive care unit. Prolonged use results in increased risk infection (VAP). In 2013, United States Centers for Disease Control and Prevention redefined monitoring quality of care for patients using ventilators by moving away from the definition ventilator-associated pneumonia (VAP) to the definition ventilator-associated event (VAE) as sustained increase in ventilator support after period of stable or decreased ventilator support. For this reason, it is necessary to search for data regarding factors that influence ventilator-associated events. The literature search method was carried out based on articles published between 2019-2024 in accordance with the inclusion and exclusion criteria that had been determined using 1 database, namely Scopus. This literature search used PRISMA guidelines in carrying out the screening process. From the search results, 60 articles were obtained. After going through the screening process, there were 3 articles that met the criteria and will be analyzed. The results of the study from 3 pieces of literature show that the factors associated with ventilator-associated events are ventilator associated-events, namely the application SDD (selective digestive decontamination), VILI (ventilator induced lung injury), lung atelectasis, excess fluid, including pulmonary edema, medication, chlorhexidine mouth rinse, spontaneous breath trials, early mobility, tracheostomy, use of vasopressors, transfusion overload, delirium, type of sedation, type sedation drug, use analgesia drugs, infection related conditions, gender, age, presence comorbidities, body mass index, disease severity index, patient's disease type, intubation reason and location.

Keywords: VAE; influencing factors

Background

In the United States, ventilator associated pneumonia is one of the causes of mortality in patients with a mortality rate of 13%. In Europe, the death rate due to early ventilator associated pneumonia is 19.2% and late ventilator associated pneumonia is 31.4%. Ventilator associated pneumonia is reported to have varying incidence rates, ranging from 9-27%. The mortality rate due to ventilator associated pneumonia can be more than 50% (4).

In 2013, the United States Centers for Disease Control and Prevention redefined monitoring of quality of care in patients on ventilators by moving from a ventilator-associated pneumonia (VAP) definition to a ventilator-associated event (VAE) definition. The VAE definition was designed to address many of the limitations of the VAP definition, including its complexity, subjectivity, limited correlation with outcomes, and incomplete description of many important and morbid complications of mechanical ventilation. The VAE definition broadens the focus of surveillance from pneumonia alone to a syndrome of nosocomial complications in patients on ventilators, characterized by a sustained increase in ventilator settings after a period of stable or decreasing ventilator settings. Qualitative studies show that most VAEs are caused by pneumonia, fluid overload, ARDS, and atelectasis. Only

approximately 40% of clinically diagnosed VAP meets VAE criteria, likely because the VAE requirement for continuous improvement in ventilator settings establishes a preferred threshold effect for critically ill patients (1).

VAE can result in patients having difficulty weaning off a ventilator and requiring longer hospital stays, resulting in a huge financial burden for patients and a high demand on medical resources. Several strategies, such as drugs including chlorhexidine, have been used to prevent VAE in the clinic. The incidence and mortality rates of VAE have decreased as prevention strategies have been developed in recent decades, but VAE remains one of the most common causes of nosocomial infections and death in intensive care units. Current challenges in the management of VAE are the lack of a gold standard for diagnosis, the absence of effective prevention strategies, and increasing antibiotic resistance. Therefore, to reduce the incidence of VAE and improve the outcome of mechanically ventilated patients, it is necessary to clarify the risk factors for VAE for clinical prevention and control of VAE (3).

Potential strategies to prevent VAE by knowing the factors that contribute to VAE include minimizing sedation, daily paired daily spontaneous breathing, early mobility, conservative fluid management, transfusion control, and low tidal volume ventilation and a limited number of studies have examined some of these interventions reported significant reductions in VAE. so far no group has assessed the impact and fully optimized VAE prevention package that includes all interventions on VAE rates and all VAE risk factors. The aim of this review is to determine the factors that influence ventilator-associated events (VAE).

This is done to create an improvement in the bureaucratic paradigm so that professional ASN can be created. Knowing the factors that play a role in influencing VAE can then carry out interventions that reduce VAE significantly and knowing the events that usually trigger VAE, helps inform the selection of strategies to prevent VAE, including all interventions on the level of VAE and all risk factors for VAE.

Methods

A literature search was carried out on articles published between 2019-2024 using the Scopus data base. Literature search using several title keywords such as "ventilator-associated event" with Boolean search methods such as "AND," and "OR," to find relevant articles that match the purpose of the writing.

Inclusion criteria in the literature search were research articles discussing factors influencing ventilator-associated events, articles in English, full text available. Exclusion criteria were gray literature, books, and other non-scientific publications. This literature search used PRISMA guidelines in carrying out the screening process. From the search results, 60 articles were obtained. After carrying out the screening process, there are 3 articles that meet the criteria and will be analyzed.

Results

Table 1.1. Article Search Results

No	AUTHOR	TITLE	RESULTS
1	Michael Klompas (2019)	Ventilator-Associated Events: What They Are and What They Are Not	Most VAEs are triggered by 1 of 4 clinical events: pneumonia (25–40% of cases), fluid overload including pulmonary edema (15–50%), atelectasis (10–15%), and ARDS (5–20%). A

			scattering of additional events are attributable to mucous plugging, pulmonary embolism, pneumothorax, poor pulmonary toilet, stroke, extrapulmonary sepsis syndromes, and transfusion-associated lung injury. In about 10–20% of cases, there is no apparent reason for the escalation of ventilator settings. Knowing the events that typically trigger VAEs helps inform the selection of strategies to prevent VAEs.
2	Sergio Ramirez-Estrada , Yolanda Peña-Lopez , Tarsila Vieceli , and Jordi Rello (2023)	Ventilator-associated events: From surveillance to optimizing management	VAE are divided into three tiers: ventilator-associated condition (VAC), infection-related ventilator-associated complication (IVAC), and possible VAP (PVAP). Factors associated with increased risk of VAE are positive fluid balance, selective oral decontamination with chlorhexidine, and stress ulcer prophylaxis while blood transfusion, use of immunomodulators, and central-line catheters are independently associated with higher rates of mortality in patients with VAE. Patients with VAE have increased risk for extubation failure, tracheotomy, disability, and death. The other related outcomes are prolonged duration of MV, longer hospital admission, and increased hospitalization costs.
3	Jordi Rello, Sergio Ramírez-Estrada, Anabel Romero, Kostoula Arvaniti, Despoina Koulenti, Saad Nseir, Nefise Oztoprak, Lila Bouadma, Loreto Vidaur, Leonel Lagunes & Yolanda Peña-López for the EUVAE Study Group (2019)	Factors associated with ventilator-associated events: an international multicenter prospective cohort study	Factors associated with VAE, adjusted by center, In the overall population, a VAE was more likely to occur in trauma or surgical patients (HR: 2.30) than in medical patients. Long-acting drugs prescription (HR: 4.30) was identified as a risk factor for VAE, whereas the use of SDD was identified as a protective factor for VAE (HR: 0.38) ($p < 0.05$). In subjects with endotracheal tube, surgical or trauma admission was also identified as a risk factor for developing a VAE (HR: 3.11); again, SDD was identified as a protective factor (HR: 0.21) ($p < 0.05$). In patients under MV for more than 7 days, the prescription of long-acting drugs was identified as a risk factor for developing a VAE (HR: 8.69) ($p < 0.05$). Factors associated with IVAC-plus are reported in

		<p>Table 3 of the electronic supplementary material section. SDD was identified as a protective factor for developing an IVAC-plus (HR: 0.31) and long-acting drugs prescribed was identified as a risk factor for IVAC-plus (HR: 3.83) ($p < 0.05$). Distribution of VAE incidences, time to VAE, duration of MV, SDD use, type of patient, and the use of long-acting drugs.</p>
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Discussion

The ventilator-associated events (VAE) definition was first released by the United States Centers for Disease Control and Prevention (CDC) in 2013. The CDC created the VAE definition to replace the old surveillance definition for ventilator-associated pneumonia (VAP). The VAE concept was designed to overcome many of the limitations of traditional VAP definitions including subjectivity, complexity, and limited association with mortality. In contrast, VAE definitions are designed to be objective, reproducible, automatable, and a strong predictor of poor outcomes (1).

VAE is identified through a combination of objective criteria, namely respiratory deterioration after a period of stability or improvement, evidence of inflammation or infection, and laboratory evidence of respiratory infection (Figure 1). This algorithm was created after research consistently highlighted the low specificity and reproducibility of diagnostic criteria used for VAP. A more reliable, objective and reproducible set of criteria is needed to carry out surveillance and ensure the effectiveness of preventive measures (2).

VAE is divided into three levels: ventilator-associated conditions (VAC), infection-related ventilator-associated complications (IVAC), and probable VAP (PVAP) (Figure 1). VAE cases that include a chart review designed to identify clinical events that trigger escalation of ventilator settings. Patients with VAE have an increased risk of extubation failure, tracheostomy, disability, and death. Other related outcomes are prolonged MV duration, longer hospital stays, and increased inpatient costs . Knowing the events that typically trigger VAEs helps inform the selection of strategies to prevent VAEs (1).

Figure 1. VAE Algorithm and Definition

Risk Factors That Can Be Intervened

The application of SDD (selective digestive decontamination) and the use of long-term sedatives and/or analgesics are variables that can be intervened, significantly influencing VAE. The influence of SDD on VAE is the presence of tracheal colonization combined with non-infectious lung pathology such as pleural effusion, atelectasis, or pulmonary edema. Preventing tracheal colonization is a mechanism used by many VAP prevention strategies such as subglottic suction, and oral decontamination (2).

VILI (ventilator induced lung injury) is the result of an imbalance between the energy used during ventilator use and lung compliance . Under normal physiological conditions, the lungs are not prepared to deal with the high pressures that may be caused by a ventilator. High tidal volumes have been used in the prevention of atelectasis, and although considered effective in the perioperative context, they have been associated with other VAEs such as VILI and barotrauma. Protective ventilation should avoid overdistension and excess pressure, limiting the opening and closing movements of the alveoli while maintaining adequate

diaphragm function. Lung-protective sedation strategies have been advocated to prevent VILI (2). Based on a two-year observation study in an Italian multicenter during the Covid-19 pandemic, where there were many ventilator users due to Covid-19, it was found that one of the factors that resulted in higher mortality within 28 days of Covid-19 patients was barotrauma (5). Meanwhile, the pathogenesis of VILI is multifactorial and complex, resulting from interactions between ventilator-related factors and patient-related factors (6).

Lung atelectasis is a common complication of mechanical ventilation, especially in perioperative patients. As obesity, extreme age, and preexisting pulmonary conditions (such as pulmonary edema and chronic obstructive pulmonary disease) increase the risk of atelectasis in perioperative patients, small increases in positive end expiratory pressure (PEEP) may decrease VAE in trauma patients. Increased PEEP levels are associated with lung overdistension and diaphragmatic atrophy(2).

Fluid overload, including pulmonary edema, accounts for up to 48% of VAEs. Fluid imbalance is associated with prolonged MV time in adults and has been established as a risk factor for VAE. The inclusion of clinically relevant pulmonary edema in the VAE algorithm is one of the biggest differences between the VAP and VAE algorithms. Preventing fluid overload is especially challenging in patients with heart and/or kidney failure and sepsis, considering that fluid resuscitation is part of the initial management (2).

ARDS accounts for 5–20% of VAE and has varied etiologies such as viral pneumonia (such as influenza and SARS-CoV-2), bacterial pneumonia, massive transfusion. Several strategies have been developed to prevent ARDS, especially regarding protective ventilation. Primary prevention of ARDS includes administering influenza and pneumococcal vaccinations, preventing aspiration pneumonitis, and using rapid sequential intubation; secondary prevention in the form of protective ventilation and preventing fluid overload; tertiary prevention includes reducing the impact of post-intensive care syndrome. Other non-infectious VAEs include pulmonary thromboembolism, mucosal obstruction, pneumothorax, and bloating. sion/compartement syndrome. Use of chlorhexidine mouthwash (0.12%, 0.2% or 2% concentration) for oral care, spontaneous breath trials, early mobility, tracheostomy, vasopressors, transfused red blood cell units, delirium, type of sedation (continuous or intermittent), sedation drugs (midazolam, propofol), as well as analgesia drugs (fentanyl, morphine, remifentanyl), increased duration of mechanical ventilation and length of stay, overall these conditions account for at least 5% of VAE (2).

IVAC-plus (infection-related VAE) was created in the 2015 VAE update to include all respiratory worsenings that follow the criteria for infection-related VAE, regardless of origin.[32] Additionally, in IVAC-plus, PVAP and IVAC should refer to pulmonary or extrapulmonary origin, respectively. The absence of microbiological confirmation does not always completely exclude pulmonary infection (as it can be caused by previous antibiotic use), and other systemic or local inflammatory responses such as autoimmune disease or lung transplant rejection that can mimic sepsis or pneumonia. In both cases, the severity of the disease and/or lack of prompt laboratory results often leads to prolonged antibiotic (2). Inappropriate use of antibiotics can result in antibiotic resistance. In 2019, antibiotic resistance caused the deaths of more than 1.2 million individuals globally. WHO estimates that by 2050 antimicrobial resistance could cause 10 million deaths worldwide. Resistant bacterial infections will have very serious consequences, including prolonged illness due to more difficult antibiotic therapy, increased mortality rates and increased medical costs (7). Therefore, limiting the use of antibiotics is very important

Risk Factors That Cannot Be Intervened

The following patient characteristics were considered as risk factors for VAE: gender, age, presence of comorbidities, body mass index, and disease severity index. High severity

was defined as an APACHE II score above 20. Patient disease type was medical, surgical, and trauma. The reasons for intubation are as follows: respiratory failure, surgery, cardiogenic shock, changes in level of consciousness, and sepsis/septic shock. Location Intubation can be performed in the ICU or elsewhere (operating room, pre-hospital, emergency unit or hospital ward)(3). Obesity was not found to be an independent risk factor for worse outcomes in patients who develop VAP in the intensive care unit. obesity is associated with prolonged duration of mechanical ventilation. Standard practice recommends performing a tracheostomy after prolonged intubation, but institutions have different policies. Thus, the possibility of tracheostomy is higher in obese patients than in non-obese patients (8). Likewise, prolonged use of a ventilator and modification of ventilator settings in adults is at risk of ventilator-associated events (9). The incidence of VEA in the ICU in patients on mechanical ventilation will increase the cost of care. There are additional costs ranging from hospitalization costs, additional costs per episode and the cost of using antibiotics, so there is a need for a standard of care for adult patients who use ventilators for a long time (10).

Conclusions and Recommendations

There are several factors that can influence the incidence of ventilator associated events that can be intervened and prevented, namely the application of SDD (selective digestive decontamination, VILI (ventilator induced lung injury), lung atelectasis, excess fluid, including pulmonary edema, use of chlorhexidine mouthwash (concentration) . 0.12%, 0.2% or 2%) for oral care, spontaneous breath trials, early mobility, tracheostomy, use of vasopressors, transfusion overload, delirium, type of sedation (continuous or intermittent), type of sedation drug (midazolam, propofol), as well as analgesia drugs (fentanyl, morphine, remifentanyl), conditions related to infection. Several factors can influence the incidence of ventilator associated events that cannot be intervened : gender, age, presence of comorbidities, body mass index, and severity index. disease. Type of patient's disease. Reason for intubation. Location. Intubation can be carried out in the ICU or elsewhere. Complications related to mechanical ventilation can increase the time on mechanical ventilation, hospital mortality rates, and hospitalization costs, thus requiring appropriate strategies to prevent VAE , including all interventions on the level of VAE and all risk factors for VAE in the intensive care unit.

Acknowledgment

Thank you to all parties involved in writing this article, especially the authors of previously published articles

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