

The Incidence and Risk Factors of Ventilator-Associated Pneumonia in ICU

Mahtab Noorifard¹, Ramin Hamidi Farahani¹, Ebrahim Hazrati²

¹ Department of Infectious Disease, School of Medicine, AJA University of Medical Sciences, Tehran, Iran

² Department of Anesthesiology and Critical Care, School of Medicine, AJA University of Medical Sciences, Tehran, Iran

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Abstract- Considering the importance of ventilator-associated pneumonia (VAP) and the high mortality rate among patients diagnosed with VAP, the aim of the current study was to evaluate the incidence of VAP, and its related risk factors in patients admitted to the intensive care unit (ICU). A total of 197 patients undergoing mechanical ventilation in the ICU diagnosed with VAP was enrolled in this study. Among these patients, 59 (53.6%) cases were male, and 51 (46.4%) were female with the mean age of 69.86 ± 14.62 years. The most common cause of ICU admission was CVA, followed by colorectal cancer, lung cancer, sepsis, and cirrhosis. Our results showed that 110 individuals (55.8%) were diagnosed with VAP. The most common bacteria were *Klebsiella*, which was found in 20.3% of cases. (47.7%) of patients had diabetes, 21.8% had chronic kidney disease, and 51.8% had cardiovascular disease. 32.7% of patients were bedridden before intubation. The mortality rate due to VAP was estimated at about 20%. In conclusion, the incidence of VAP in ICU is relatively high (55.8%), with a mortality rate of 20%. Among the risk factors, the presence of diabetes, bedridden, reduction in consciousness, and the time duration of mechanical ventilation are relative to this type of infection.

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Introduction

It has been observed that the incidence of Ventilator-Associated Pneumonia (VAP) varies from 10 to 25% of all patients admitted to ICU. In addition, VAP is significantly associated with increased mechanical ventilation duration, length of hospital stay, intensive care unit, and increased hospital treatment costs (1). Besides, previous studies have demonstrated that the likelihood of deaths in patients diagnosed with VAP might be increased by up to 30%, which is 6-21 times higher in the intubated patients (2).

VAP occurred when an infection factor such as bacterial, viral, and fungal pathogens enter the sterile area of the lower respiratory tract or lung parenchyma. It has been well documented that VAP is usually caused by *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Acinetobacter baumannii*. Also, *Staphylococcus aureus* accounts for approximately 20% of patients diagnosed with VAP (3-5). On the other hand, the overgrowth of gram-negative bacteria in the upper gastrointestinal tract might be one of the causes of VAP. In addition, the elderly males, history of sinusitis, low pressure of air-

filled endotracheal tube, long duration of intubation, and etc. are considered as the risk factors of VAP (6). Based on the previous studies, the diagnosis of VAP includes a combination of new or persistent infiltrates on chest radiographic studies and the two of the following factors, including high temperature (greater than 38.3), leukocytosis, or purulent tracheal secretions (7).

It has been shown that the current preventive approaches for VAP are mainly directed at colonization and aspiration, such as avoiding intubation (8), oral care (9), assessing for early weaning and mobility (10-12), and prophylactic probiotics and antibiotics (13). Recently it was shown that the usage of broad-spectrum antibiotics had been increased in patients diagnosed with VAP due to increasing the incidence of multidrug-resistant (MDR) infections (14). Although prevention efforts might decrease the incidence of VAP, unfortunately, only a few preventive strategies have been indicated to be effective in managing VAP, while many others should be further evaluated in large randomized trials before becoming the clinical recommendations (15). In this regard, reducing the incidence of VAP remains a critical element of the

Corresponding Author: E. Hazrati

Department of Anesthesiology and Critical Care, School of Medicine, AJA University of Medical Sciences, Tehran, Iran
Tel: +98 2143825240, Fax: +98 2142910703, E-mail address: Dr.hazrati.e@gmail.com

management for individuals admitted to intensive care units and needing mechanical ventilation. Based on the importance of VAP and the high mortality rate in patients requiring mechanical ventilation, this study aimed to investigate the incidence of VAP and its related factors and identify common organisms in intubated individuals admitted to ICU.

Material and Methods

The current descriptive and retrospective study was evaluated the incidence of VAP and its related factors in 197 individuals undergoing mechanical ventilation for more than 48 hours in ICUs of Imam Reza Hospital. Patients were enrolled in this study based on the inclusion criteria in following (16-18):

1. Patients who underwent at least 48 hours of mechanical ventilation.
2. Patients diagnosed with VAP based on the following criteria:
 - a. New or developing abnormalities in radiographic studies.
 - b. Body temperature higher than 38 degrees centigrade.
 - c. Leukocytosis ($\geq 12,000$), or leukopenia ($< 4,000$).
 - d. Purulent discharge.

On the other hand, individuals with cardiac or lung transplantations, massive hemoptysis, and patients with hemodynamic changes were excluded from this study. In addition, we excluded individuals with the age of lower than 18 and patients who had been transferred from another hospital while undergoing mechanical ventilation.

The chi-square analyses were used to analyze the data in the current study by using SPSS version 24. $P < 0.05$ was a critical criterion for statistical significance.

Results

In our study, 336 individuals were admitted to the ICU. Of these, 207 individuals underwent mechanical ventilation. Finally, 197 patients were enrolled in this study based on the inclusion criteria. The mean age of

individuals was 69.86 ± 14.62 , with a maximum of 96-year-old. The mean hospitalization time 23.21 ± 15.06 , with a minimum of 4 and a maximum of 90 days. In addition, we evaluated the APACHE II score after admission. The mean APACHE II score was 20.34 ± 2.82 , with a maximum of 25 and a minimum of 12. In this study, we evaluated the cause of ICU admission. The most prevalent cause of ICU admission was a cerebrovascular accident (CVA) and followed by colorectal cancer, lung cancer, sepsis, and cirrhosis.

Our results showed that 110 (55.8%) individuals were diagnosed with VAP based on the VAP criteria. Based on the result of bacterial culture, the most prevalent cause of VAP was *Klebsiella* (20.3%) and followed by *Citrobacter* (16.8%), *Acinetobacter* (14.2%), and *Enterobacter* (4.6%).

Chi-square analysis between gender and the prevalence of VAP showed that VAP had not any association with gender ($P=0.83$, Table 1). Also, our analysis showed that diabetes was significantly associated with the prevalence of VAP ($P=0.001$, Table 1). In addition, our analysis failed to show any association between chronic kidney disease and the prevalence of VAP by using the Chi-square test ($P=0.7$, Table 1). Based on our results, the prevalence of VAP had not any association with cardiovascular diseases ($P=0.88$, Table 1). In this study, we observed that the bedridden condition is a strong risk factor for VAP ($P=0.014$, Table 1). Both chronic lung diseases and loss of consciousness are associated with the prevalence of VAP ($P=0.012$ and $P=0.048$, respectively). Malignancies, central venous catheter, past history of corticosteroid and H2 blocker usage, past history of antibiotic usage, long sedation treatment, and past history of trauma were not associated with the prevalence of VAP ($P=0.693$, $P=0.768$, $P=0.17$, $P=0.668$, $P=0.876$, $P=0.972$, and $P=0.77$, respectively). Finally, our results showed that patients who underwent ventilation for more than two days were significantly associated with the prevalence of VAP ($P=0.0001$); also, the prevalence of VAP was significantly associated with a mortality rate ($P=0.009$).

On the other hand, Table 2 shows the results of our bacterial culture analysis and the resistance of each type to their reference antibiotics.

Table 1. Evaluation of the risk factors of VAP

Items		Diagnosed with VAP		P
		Yes	No	
Genders	Male	59 (53.6%)	48 (55.2%)	0.83
	Female	51 (46.4%)	39 (44.8%)	
History of CVD	Positive	46 (52.9%)	57 (51.8%)	0.883
	Negative	41 (47.1%)	53 (48.2%)	
History of diabetes	Positive	47 (42.7%)	18 (20.7%)	0.001*
	Negative	63 (57.3%)	69 (57.3%)	
History of CKD	Positive	24 (21.8%)	21 (24.1%)	0.7
	Negative	86 (78.2%)	66 (75.9%)	
Bedridden condition	Positive	36 (32.7%)	15 (17.2%)	0.014*
	Negative	72 (82.8%)	74 (67.3%)	
History of malignancy	Positive	50 (45.5%)	42 (48.3%)	0.693
	Negative	60 (54.5%)	45 (51.7%)	
History of CVC	Positive	66 (60%)	54 (62.1%)	0.768
	Negative	44 (40%)	33 (37.9%)	
History of Corticosteroid	Positive	22 (20%)	11 (12.6%)	0.17
	Negative	88 (80%)	76 (87.4%)	
History of H2 Blocker	Positive	102 (92.7%)	82 (94.3%)	0.668
	Negative	8 (7.3%)	5 (5.7%)	
History of antibiotics	Positive	77 (70%)	60 (69%)	0.876
	Negative	33 (30%)	27 (31%)	
Long sedation treatment	Positive	9 (8.2%)	7 (8%)	0.972
	Negative	101 (91.8%)	80 (92%)	
History of trauma	Positive	3 (2.7%)	3 (3.4%)	0.77
	Negative	107 (97.3%)	84 (96.6%)	
History of CLD	Positive	25 (22.7%)	8 (9.2%)	0.012*
	Negative	85 (77.3%)	79 (90.8%)	
History of LOC	Positive	71 (64.5%)	44 (50.6%)	0.04*
	Negative	39 (35.5%)	43 (49.4%)	
Duration of ventilation	More than 2 days	107 (97.3%)	72 (82.8%)	0.0001*
	Less than 2 days	3 (2.7%)	15 (17.2%)	
Death	Positive	22 (20%)	6 (6.9%)	0.009*
	Negative	88 (80%)	81 (93.1%)	

Table 2. Antibigram of culture in individuals diagnosed with VAP

Antibiotics		Acinetobacter	Klebsiella	Citrobacter	Enterobacter
Tetracycline	Resistance	19.2	-	-	-
	Sensitivity	80.8	-	-	-
Amikacin	Resistance	18.5	40	78.8	-
	Sensitivity	81.5	60	21.2	-
Ceftriaxone	Resistance	78.6	-	90.6	33.3
	Sensitivity	21.4	-	9.4	66.7
Ciprofloxacin	Resistance	28.6	-	-	-
	Sensitivity	71.4	-	-	-
Ceftazidime	Resistance	21.4	12.5	-	-
	Sensitivity	78.6	87.5	-	-
Cefoxitin	Resistance	25	-	-	-
	Sensitivity	75	-	-	-
Nalidixic acid	Resistance	14.3	77.5	-	-
	Sensitivity	85.7	22.5	-	-
Imipenem	Resistance	67.9	92.5	78.1	-
	Sensitivity	32.1	7.5	21.9	-
Erythromycin	Resistance	15.4	-	-	-
	Sensitivity	84.6	-	-	-
Cefotaxime	Resistance	-	-	84.4	11.1
	Sensitivity	-	-	15.6	88.9
Gentamycin	Resistance	-	-	-	88.9
	Sensitivity	-	-	-	11.1

Discussion

In this study, we observed the high prevalence of VAP in patients undergoing mechanical ventilation in ICU. In addition, we showed a high mortality rate due to VAP. Besides, we indicated that diabetes, bedridden condition, chronic lung disease, history of loss of consciousness, and long duration of intubation might be the risk factors of VAP in ICU.

In the current report, among 197 intubated patients, 110 individuals (55.8%) were diagnosed with VAP. Afkhamzadeh *et al.*, (19) were evaluated the prevalence of VAP in 2011. The results of the recently mentioned study showed that the prevalence of VAP estimated about 32.2% in ICU. While Naderi *et al.*, (20) showed that the prevalence of VAP in individuals with a past history of hospital-acquired pneumonia was 66.5%. Besides, numerous studies have estimated the prevalence rate of VAP in India (35.9%), the Netherlands (45.9%), and Singapore (73%) (21,22). These variations might be due to numerous approaches in the diagnosis of VAP and the variations of the target population. In addition, the severity of underlying diseases and the cause of the admission or indication of intubation could play a key role in the rate of prevalence. Moreover, most studies have focused on the prevention approaches to reduce the prevalence rate of VAP (23,24).

In the current study, the mean age of patients was 69.86 ± 14.62 , and the mean hospitalization time was 23.21 ± 15.06 days. Among individuals diagnosed with VAP, 97.3% was intubated for more than two days. In addition, the most prevalent cause of VAP was *Klebsiella* and followed by *Citrobacter*, *Acinetobacter*, and *Enterobacter*, respectively. Raad *et al.*, in 2010 showed that the most prevalent pathogen of VAP was methicillin-resistant *Staphylococcus aureus* (MRSA) and followed by *Pseudomonas Aeruginosa*, *Acinetobacter Baumannii*, *Klebsiella*, *Enterobacter*, and *Candida Albicans* (25). However, Nadi *et al.*, (26) indicated that the gram-negative bacteria were the most common cause of VAP. In line with the previously mentioned study, in another study, the most prevalent cause of VAP was the gram-negative bacteria.

In the current study, the VAP was not associated with gender, history of CVD, history of CKD, history of malignancies, history of drug usages such as corticosteroid, antibiotic, and H₂ blockers, and the duration of sedation treatment. While, we observed that

diabetes, bedridden condition, chronic lung disease, history of loss of consciousness, and long duration of intubation were the risk factors of VAP. Previous studies showed that the history of H₂ blocker treatment could increase the prevalence of VAP due to the high growth rate of bacteria in alkaline environments (27,28). However, we did not observe any association between the history of the H₂ blocker and the prevalence of VAP. Therefore, based on the result of the current study using an H₂ blocker not only could prevent the peptic ulcer in intubated individuals but also could not be a risk factor for VAP. Finally, we observed a high mortality rate among individuals diagnosed with VAP. In line with our results, past studies showed that VAP is a critical and life-threatening condition (29).

In this study, we concluded that the most prevalent pathogenesis of VAP was a gram-negative bacterium. Also, based on our results, diabetic patients, individuals with a history of loss of consciousness, bedridden individuals, and individuals diagnosed with chronic lung disease are at risk of VAP after undergoing mechanical ventilation. In addition, we observed that the long duration of mechanical ventilation is strongly associated with VAP. Therefore, decreasing the time duration of mechanical ventilation could decrease the prevalence of VAP. Finally, using the H₂ blocker was not associated with VAP; thus, these agents are safe to use for preventing the peptic ulcer in intubated individuals.

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The incidence and risk factors of ventilator-associated pneumonia

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