Original Article

Risk Factors for Ventilator-Associated Pneumonia in Tertiary Care Hospitals

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Abstract

Introduction. In El Salvador, ventilator associated pneumonia is the third most frequent health care-associated infection, it has a high impact because it raises attention costs. **Objective.** Analize the risk factor for the development of ventilator associated pneumonia in tertiary care hospitals in El Salvador during 2022. **Methodology.** It was a case-control study, we calculated the sample with a 95 % confidence level, 80 % statistical power, Odds ratio (OR) of 2.5 and a 3 controls per case ratio. Cases were ventilated patients diagnosed with pneumonia between January and December 2022 who have a confirmed microbiological isolation in a respiratory sample, Controls were patients without pneumonia for at least 72 hours after extubation, the information was obtained from the clinical files. We used a logistic regression model to determine risk factors. **Results.** We reviewed 206 clinical files, 52 cases and 154 controls, the most frequent sign of infection was leukocytosis, it was present in 78.6 % of cases. The most isolated pathogen was *Acinetobacter baumannii* , reported in 27.8 % of cultures. Male gender (OR: 4.94 CI95 %:1.56-15.66), history of trauma (OR:10.52 CI95 %: 2.73-40.59) and intubation days (OR: 1.24; CI95 %: 1.14-1.36) were statistically significant independent risk factors. **Conclusion.** Male gender, history of trauma and intubation days were risk factors for ventilator associated pneumonia in tertiary care hospitals from El Salvador during 2022.

Keywords

Pneumonia Ventilator-Associated, Cross Infection, Respiration, Artificial, Risk Factor.

Resumen

Introducción. En El Salvador la neumonía asociada a ventilación mecánica es la tercera infección más frecuente asociada a la atención sanitaria, con un alto impacto por sus costos de atención. **Objetivo.** Analizar los factores de riesgo para desarrollar neumonía asociada a ventilación mecánica en hospitales de tercer nivel de El Salvador durante el 2022. **Metodología.** Estudio de casos y controles, la muestra se calculó para un nivel de confianza del 95 %, potencia del 80 %, Odds ratio (OR) de 2,5, y con una relación de tres controles por caso. Los criterios de inclusión para casos fueron pacientes ventilados que se diagnosticaron como neumonía durante el 2022 con confirmación bacteriológica por cultivo de secreción respiratoria, los controles fueron pacientes con ventilación mecánica mayor a 48 horas sin neumonía posterior a 72 horas de extubación, la información se obtuvo de los expedientes clínicos. Se utilizó un modelo de regresión logística para determinar los factores de riesgo. **Resultados.** Se revisaron 206 expedientes, 52 casos y 154 controles, el dato de laboratorio más frecuente fue la leucocitosis con un 78,6 % de los casos, y el patógeno aislado con mayor frecuencia fue *Acinetobacter baumannii* con 27,8 % de aislamientos; el sexo masculino (OR: 4,94; IC95 %: 1,56-15,66), el trauma (OR: 10,52; IC95 %: 2,73-40,59) y los días de intubación (OR: 1,24; IC95 %: 1,14-1,36) fueron factores independientes de riesgo estadísticamente significativos. **Conclusión.** El sexo masculino, el antecedente de trauma y los días de intubación fueron factores de riesgo para neumonía asociada a ventilación mecánica en hospitales de tercer nivel de El Salvador.

Palabras clave

Neumonía Asociada al Ventilador, Infección Hospitalaria, Ventilación Mecánica, Factores de Riesgo.

Introduction

Worldwide, in both developed and developing countries, healthcare-associated infections (HAIs) are an important cause of morbidity and mortality in patients receiving care in health centers.[i-iii] Pneumonia is one of the most frequent HAIs worldwide,[i,iv,v] and as a result of the difference in etiology, diagnosis and management, it is classified as non-ventilator-associated pneumonia (NVAP), when it develops 48 hours after hospital admission in a non-ventilated patient, and ventilator-associated pneumonia (VAP)

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Factores de riesgo para neumonía asociada a ventilación mecánica en hospitales de tercer nivel.

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if it is diagnosed in a patient on mechanical ventilation (MV) 48 hours after the onset of MV.[vi] If pneumonia appears between two to four days of MV, it is called early VAP, and after this time it is considered late VAP.[vii]

The diagnosis and management of VAP is especially challenging in low-income countries, not only because of limited resources, but also because of the presence of unique demographic characteristics that may influence the etiology and evolution of the disease.[viii] There is no gold standard for the diagnosis of VAP, the use of scores has been proposed, one of the most widely used is the Clinical Pulmonary Infection Score (CPIS) which evaluates temperature, blood leukocytes, tracheal secretions, oxygenation, radiological findings and respiratory secretion culture. The range of the score is from 0 to 12, a score greater than or equal to seven is suggestive of VAP.[ix,xi]

According to the World Health Organization (WHO) Report on the burden of endemic health care-associated infection worldwide published in 2011, the cumulative incidence density of VAP in high-income countries was 7. 9 (95 % CI: 5. 7-10. 1) per 1000 ventilator-days, while in low and middle-income countries, it was 23. 9 (95 % CI: 20. 7-27. 1).[i] VAP can prolong MV by 4-6 days, and crude mortality is estimated at 16-78 %, although it is difficult to determine whether patient death is caused by pneumonia or by other underlying conditions present in critically ill patients;[xii] an attributable mortality of up to 30 % has been estimated.[i,xii]

There is a wide variety of risk factors for developing VAP, some are modifiable such as patient position, sedation, tracheostomy, and antibiotic use; while others are not modifiable such as chronic diseases, male gender, trauma, state of consciousness, surgical interventions, and age over 60 years.[xiii-xviii] Two important factors are the intubation duration and the length of hospital stay. The longer the patient remains connected to the ventilator, the greater the risk of infection, since the presence of the endotracheal tube favors colonization of the airway by microorganisms, also the contamination probability of the humidifiers and ventilation circuits increases with time.[xiv]

In El Salvador, we did not find published data related to the excess costs resulting from VAP, but other studies estimate the cost of care to be between $10 000 USD and $40 000 USD per event depending on health costs and the conditions of each country; in some cases, the cost of care rises to around $100 000 USD if more variables are taken into account.[xix] Therefore, an investigation was proposed with the objective of analyzing the risk factors for developing pneumonia associated with mechanical ventilation in third level hospitals of the Ministry of Health, and the most frequently isolated pathogens during 2022.

Methodology

An analytical observational case-control study was conducted in three tertiary level hospitals of the Ministry of Health of El Salvador: Benjamín Bloom National Children's Hospital (HNNBB), Dr. María Isabel Rodríguez National Women Hospital (HNM) and Rosales National Hospital (HNR). Data were obtained from clinical files.

The case definition was any mechanically ventilated patient admitted between January and December 2022 with a CPIS score greater than or equal to seven and the control definition was any mechanically ventilated patient admitted between January and December 2022 with a score less than seven.

The inclusion criteria for the cases were patients diagnosed as VAP with bacteriological confirmation by culture of respiratory secretion. Cases were excluded if the clinical record was not available for review or if they had been referred from another hospital center with a diagnosis of VAP.

The inclusion criteria for the controls were patients with MV greater than 48 hours and without a diagnosis of pneumonia from the start of MV until 72 hours after extubation with negative culture of respiratory secretion for bacterial growth; controls in which the clinical record was not available for review or who were referred from another hospital center more than 48 hours after the start of mechanical ventilation were excluded.

The variables analyzed were sex, age at admission, chronic diseases, history of trauma of any type, Glasgow Coma Scale at admission, history of HAI, previous surgeries, previous antibiotics, days of intubation, ICU days and days of in-hospital stay. In addition, temperature, leukocyte count, presence of purulent discharge and presence of radiological infiltrate at the time of VAP diagnosis were recorded in the cases. Microbiological isolation and respective antimicrobial resistance were also described. In those cases, with more than one episode of VAP during their hospital stay, information was collected for the first episode. Cases were matched by hospital for the analysis.

Because this study is a review of clinical files, it was not possible to include variables that are not routinely recorded in

them, such as intubation technique, hand washing of health personnel before providing care and performing procedures, and maintenance of ventilation circuits. In addition, it was not possible to analyze pneumonias caused by other microorganisms such as viruses and fungi due to the difficulty of their diagnosis.

The sample size was determined with the StatCalc calculator of the EpiInfo software version 7. 2. 6, for a 95 % confidence level, 80 % power, an OR of 2. 5, a ratio of 3 controls per case, and a proportion of controls with exposure of 40 %. We sampled proportionally to the VAP reported by each hospital during 2022. To determine the cases to be included in the investigation, a random selection was made from the registry of patients reported as clinical diagnosis of VAP in the HCAI surveillance of each hospital; and to choose the controls, randomization was performed in the registry of patients discharged with ICU hours during 2022.

The selected files were requested from the Department of Statistics and Medical Documents of each hospital, then the information was collected in a digital instrument elaborated with the EpiInfo program, divided into identification data, clinical characteristics, bacterial resistance and risk factor information.

Qualitative variables were analyzed using frequencies and proportions, the normality of quantitative variables was evaluated with the Anderson Darling test, and measures of central tendency and dispersion were calculated according to the nature of the data. To determine the association between categorical variables and the risk of VAP, we calculated Odds Ratio (OR) and we used 95 % confidence intervals and p value calculated with the Chi-Square method to determine the statistical significance of the findings.

We used The Mann Whitney U test to analyze the difference between the case and control groups for continuous variables. We used a binary logistic regression for the multivariate analysis of the risk of developing VAP, we evaluated the validity of the model with the Likelihood Ratio test. The EpiInfo Version 7. 2. 6 program and the Microsoft Excel RealStatistic add-in were used for data analysis.

All the information obtained was treated confidentially, no names, document numbers or any information that could lead to the identification of patients were collected, and approval was obtained from the ethics committees of each hospital.

Results

The study included 206 patients, 52 cases, and 154 controls. We assigned eight cases and 24 controls to HNNB, eight cases and 24 controls to HNM, and 36 cases with 106 controls to HNR. The proportion of males was higher in the cases (69. 2 %) than in controls (47, 4 %), 40. 4 % (21/52) of the cases were admitted for trauma compared to 16. 9 % (26/154) of controls, 50 % (26/52) of the cases presented an HAI before the diagnosis of VAP, and 23. 4 % (36/154) of the controls presented HAIs during the duration of MV; the most frequent chronic diseases in both cases and controls were arterial hypertension and diabetes *mellitus* (Table 1).

Among the diseases included in "Others" are epilepsy at 2. 4 % (5/206), chronic liver disease at 1. 9 % (4/206), hypothyroidism at 1 % (2/206), and meningioma at 1 % (2/206). Each of the following: chronic obstructive pulmonary disease (COPD), bilateral hydronephrosis, congenital hypothyroidism, renal lithiasis, myasthenia gravis, myelomeningocele, potassium-losing tubulointerstitial nephropathy, idiopathic thrombocytopenic purpura, deep vein thrombosis, and human immunodeficiency virus (HIV) infection had a proportion of 0. 5 % (1/206).

Among cases with trauma, 57. 1 % (12/21) were classified as cranioencephalic trauma (CET), 28.6 % (6/21) as multiple traumas, 9. 5 % (2/21) as abdominal trauma, and 4. 8 % (1/21) as limb trauma. In comparison, 46. 2 % (12/26) of the controls were classified as multiple traumas, 38. 5 % (10/26) as TBI, 11. 5 % (3/26) as burns, and 3. 9 % (1/26) as spinal trauma.

Of the cases, 92. 3 % (48/52) received antibiotics prior to the diagnosis of VAP, 84. 4 % (130/152) of the controls received antibiotic treatment during the MV period, 81. 3 % (39/48) of the cases treated with antibiotics, and 91. 5 % (119/130) of the controls with antibiotic therapy received beta-lactams, this being the most frequently recorded antimicrobial in this investigation.

The median age of cases was 37. 5 (IR: 1 - 56. 5 years), and in controls it was 33. 5 years (IR: 3 - 60 years). The median number of hospital stay in the cases was 34 days (IR: 23. 5 - 65. 5 days), and in the controls was 15. 5 days (IR: 10 - 29 days). The median of ICU stay in cases was 25. 5 days (IR: 17 - 52 days), while in controls it was seven days (IR: 5 - 14 days). The median number of intubation time in cases was 16 days (IR: 11 - 31 days) and in controls was 5 days (IR: 2 - 8 days) (Figure 1).

Table 1. Clinical characteristics of mechanically ventilated patients in tertiary level hospitals in 2022

	Cases (N: 52)		Controls (N: 154)		Total (N: 206)	
Variable	N	%	N	%	N	%
Male	36	69.2	73	47.4	109	52.9
Female	16	30.8	81	52.6	97	47.1
Deceased	21	40,4	56	36,4	77	37,4
Age						
Under 1 year old	12	23.1	33	21.4	45	29.2
1 to 12 years	4	7.7	10	6.5	14	6.8
13 to 17 years	-	-	8	5.2	8	3.9
18 to 65 years	29	55.8	76	49.4	105	51.0
Over 65 years	7	13.5	27	17.5	34	16.4
Chronic diseases						
Arterial hypertension	11	21.2	33	21.4	44	21.4
Diabetes *mellitus*	7	13.5	20	13	27	13.1
Cancer	5	9.6	20	13	25	12.1
Chronic kidney disease	7	13.5	9	5.8	16	7.8
Cardiovascular disease	2	3.9	11	7.1	13	6.3
Others	10	19.2	16	10.4	26	12.6
Diagnoses and treatments received						
Trauma	21	40.4	26	16.9	47	22,8
Previos HAI[a]	26	50	36	23.4	62	30.1
Tracheostomy	6	11.5	10	6.5	16	7.8
Previous surgery	29	55.8	74	48.1	103	50
Previous antibiotic	48	92.3	130	84.4	178	86.4

a. Healthcare associated infection

We obtained a p-value < 0. 05 in the Mann-Whitney U test for the difference in hospital stay, ICU stay, and intubation time between cases and controls, so we concluded that this difference was statistically significant; the difference between the median ages was not statistically significant (p > 0. 05).

For the Glasgow Coma Scale score analysis, only data from patients admitted for trauma were analyzed, of which 89. 4 % (42/47) were admitted to the HNR and 10. 6 % (5/47) to the HNNBB. The median for cases was six points (RI: 3 - 11 points), and for controls, it was eight points (RI: 6 - 12 points). The difference was not statistically significant (p > 0. 05).

Among the signs and symptoms investigated at the time of VAP diagnosis, 42. 3 % (22/52) of the cases had fever, 32. 7 % (17/52) purulent discharge, 78. 8 % (41/52) leukocytosis, 13. 5 % (7/52) localized radiological infiltrate and 21. 2 % (11/52) diffuse radiological infiltrate. The mean temperature at diagnosis of VAP was 37. 5°C (SD: 0 9°C), and the median leukocyte count was 15 240/mm^3 (IR: 11 900 - 25 955/mm^3). 19. 2 % (10/52) of the cases of pneumonia were classified as early VAP. The median time between intubation and VAP diagnosis was 8. 5 (IR: 5 - 12 days), the median of ICU stay until VAP diagnosis was 8 days (IR: 5 - 12. 5 days) and the hospital admission time until VAP diagnosis was 10 days (IR: 5. 5 - 19 days).

We obtained 54 isolates because two cultures reported coinfection by two bacteria. In one, we detected *Klebsiella pneumoniae* and *Staphylococcus aureus*, while in the other, *Pseudomonas aeruginosa* and *K. pneumoniae* were isolated. Both samples are from pediatric patients and both are late VAP. *Acinetobacter baumannii* , *K. pneumoniae*, and *P. aeruginosa* were the most frequently isolated agents (Table 2).

We found that 87 % (47/54) of the isolates reported resistance to one or more antibiotics, 100 % of *A. baumani* (15/15), *Escherichia coli* (5/5), *S. aureus* (3/3), *E. cloacae* (1/1), *P. putida* (1/1) isolates, 92. 9 % (13/14) of *K. pneumoniae* and 80. 0 % (8/10) of *P. aeruginosa* isolates reported resistance to one or more antibiotics. Also 100 % of *S. maltophila* (3/3) and *P. stutzeri* (1/1) isolates reported resistance to no antibiotics resistance.

Of the microorganisms isolated in early VAP patients, 60 % (6/10) were resistant to one or more antibacterials, while among

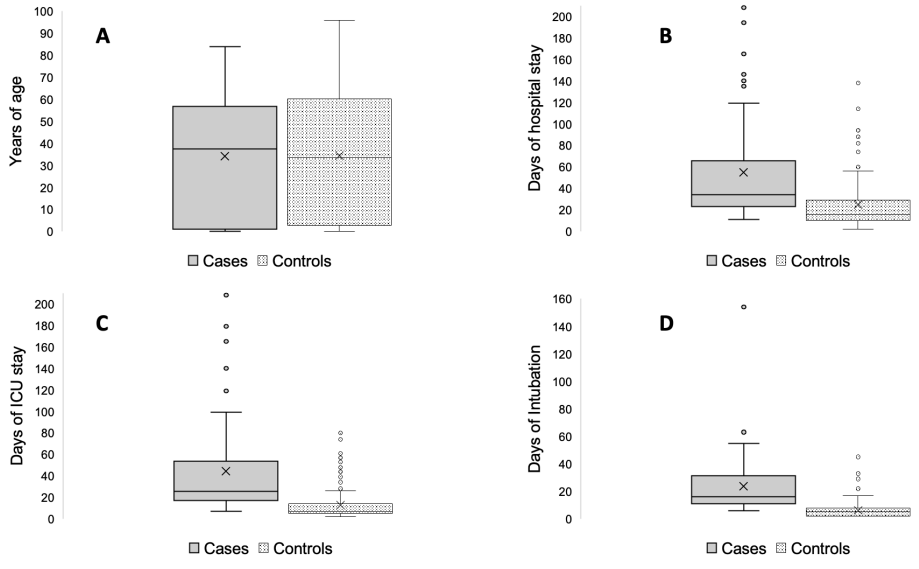

Figure 1. Comparison of median age, days of hospital admission, days of ICU stay and days of intubation of patients in tertiary level hospital in El Salvador in 2022. A) Years of age B) Days of hospital Stay C) Days of ICU stay D) Intubation days

late VAP patients, 93. 2 % (41/44) of the isolates were resistant. Of the organisms isolated in early VAP, 30 % (3/10) were *K. pneumonia* and 20 % (2/10) were *S. maltophila*, the rest were: *A. baumani*, *E. cloacae*, *P. aeruginosa*, *P. stutzeri and S. aureus* all with 10 % (1/10). In late VAP 31. 8 % (14/44) were *A. baumani,* 25 % (11/44) were *K. pneumoniae*, 20. 5 % (9/44) were *P. aeruginosa*, 11. 4 % (5/44) were *E. coli,* and 4. 6 % (2/44) were *S. aureus*, while *P. luteola, P. putida* and *S. maltophila* accounted for 2. 3 % (1/44) of the cases of late VAP.

The results of the bivariate analysis for the risk of VAP are listed in Table 3. We found that male gender with an OR of 2. 49 (95 % CI: 1. 28 - 4. 95), history of trauma with an OR of 3. 31 (95 % CI: 1. 64 - 6. 69), and previous HAI with an OR of 3. 26 (95 % CI: 1. 68 - 6. 35) were statistically significant risk factors for developing VAP.

The results of the logistic regression used for multivariate analysis are shown in Table 4. We found that male gender with OR of 4. 49 (95 %CI: 1. 56 - 15. 66), history of trauma with OR of 10. 52 (95 %CI: 2. 73 - 40. 59), and days of intubation with OR of 1. 24 (95 %CI: 1. 14 - 1. 36) have a statistically significant association with the development of VAP.

Table 2. Isolated bacteria in VAP cases in tertiary hospitals by 2022

Bacterial isolation	Frequency	%
Acinetobacter baumannii	15	27,8
Klebsiella pneumoniae	14	25,9
Pseudomonas aeruginosa	10	18,5
Escherichia coli	5	9,3
Staphylococcus aureus	3	5,6
Sthenotorphomona maltophila	3	5,6
Enterobacter cloacae	1	1,9
Pseudomonas luteola	1	1,9
Pseudomonas putida	1	1,9
Pseudomonas stutzeri	1	1,9
Total	54	100

Table 3. Analysis of factors associated with the development of VAP in tertiary hospitals in El Salvador 2022

Variable	Cases (N: 52)		Controls (N: 154)					
	N	%	N	%	OR	IC95 %		P-Value
Male gender	36	69.2	73	47.4	2.5	1.3	5.0	0.010
Over 65 years	7	13.5	27	17.5	1.4	0.6	3.6	0.640
Tracheostomy	6	11.5	10	6.5	1.9	0.6	5.5	0.381
Arterial hypertension	11	21.2	33	21.4	1.0	0.4	2.1	1.000
Diabetes *mellitus*	7	13.5	20	13.0	1.0	0.4	2.6	1.000
Cancer	5	9.6	20	13.0	0.7	0.2	1.9	0.629
Chronic kidney disease	7	13.5	9	5.8	2.5	0.8	7.2	0.140
Cardiovascular disease	2	3.9	11	7.1	0.5	0.1	2.2	0.524
Trauma	21	40.4	26	16.9	3.3	1.6	6.7	0.001
Thoracic surgery	3	10.3	11	14.9	0.7	0.2	2.3	0.766
Abdominal surgery	8	27.6	21	28.4	1.2	0.5	2.7	0.852
Previos HAI	26	50.0	36	23.4	3.3	1.7	6.4	0.001
Previous antibiotic	48	92.3	130	84.4	2.2	0.8	7.8	0.169

Table 4. Logistic regression to determine factors associated with the development of VAP.

Variable	OR	IC95%		Coefficient	S.E*	Z-Statistic	P-Value
Male gender	4.9	1.6	15.7	1.598	0.588	2.715	0.007
Trauma	10.5	2.7	40.6	2.354	0.689	3.417	0.001
Previos HAI	0.8	0.2	2.7	-0.249	0.639	-0.390	0.696
Tracheostomy	0.5	0.1	3.0	-0.721	0.922	-0.782	0.434
Arterial hypertension	1.4	0.3	7.9	0.358	0.872	0.411	0.681
Diabetes *mellitus*	3.3	0.7	15.8	1.196	0.798	1.499	0.134
Cancer	3.0	0.5	19.4	1.098	0.952	1.153	0.249
Chronic kidney disease	1.8	0.3	11.7	0.608	0.944	0.644	0.520
Cardiovascular disease	0.3	0.0	5.5	-1.288	1.527	-0.844	0.399
Thoracic surgery	0.3	0.0	6.1	-1.071	1.472	-0.727	0.467
Abdominal surgery	2.7	0.7	10.9	0.984	0.716	1.374	0.169
Previous antibiotic	0.9	0.2	4.7	-0.112	0.844	-0.133	0.895
Intubation days	1.2	1.1	1.4	0.219	0.047	4.670	0.000
Days of ICU stay	1.0	1.0	1.1	0.035	0.021	1.628	0.104
Days or hospital stay	1.0	1.0	1.0	-0.005	0.017	-0.330	0.742
Age	1.0	1.0	1.0	0.009	0.014	0.651	0.515

*Standard Error

The model was evaluated using the likelihood ratio test, we obtained a p-value < 0.05 and we concluded that a model with variables better predicts the occurrence of VAP than a null model.

Discussion

The result of both bivariate and multivariate analyses determined that male gender is a risk factor for VAP. Multiple studies report a higher incidence of VAP and a higher risk of acquiring pneumonia in men,[xiv,xv,xx-xxv] this difference could be due to sex hormones or genetic polymorphisms related to the immune response to infectious agents.[14,26]

There are publications where, as in this study, trauma is identified as a risk factor for developing VAP,[xiii,xiv,xxvii] including a retrospective cohort of 2591 mechanically ventilated patients which, in addition to concluding that this type of patient has a higher incidence of VAP, determined that these patients had more days of hospital admission, more days in the ICU and more time on mechanical ventilation.[xxviii]

The longer hospital stay and greater number of procedures make these patients more vulnerable to other HAIs, such as transurethral catheter-associated infection or catheter-associated bacteremia. This may be the reason that in the bivariate analysis, previous HAIs were a risk factor for VAP but were discarded in the regression model.

It is not clear why trauma patients are more likely to develop VAP, however, as part of the immune response to trauma, a proinflammatory state is produced that can trigger respiratory and multiorgan failure, subsequently initiating an anti-

inflammatory counter-regulatory reaction that can lead to immunosuppression and make the patient vulnerable to infectious processes.[xxix]

We also identified the duration of mechanical ventilation as a statistically significant variable for increasing the risk of VAP, which is consistent with findings reported in other publications;[xx,xiv,xv,xxvi,xxx-xxxii] the presence of an orotracheal tube alters defense mechanisms against infection, reduces the ability of respiratory cilia to dislodge secretions, provides direct entry into the airway for microorganisms, allows the development of biofilms, and impairs the cough reflex; additionally, contamination may occur during the secretion aspiration procedure.[xx,xiv]

The length of stay in the ICU has been identified as a risk factor in other studies;[xxxi,xxxiii] in this study, although the Mann-Whitney test determined a statistically significant difference between cases and controls, logistic regression found no association with an increased risk of VAP. The length of stay in the ICU is dependent on the intubation time, due to the fact that patients undergoing MV remain in the ICU.

While some publications determined that tracheostomy was associated with an increased risk of developing VAP,[xiv,xx,xxii,xxviii] in other studies this proved to be a protective factor;[x,xxvi] in this study no statistical significance was found. Tracheostomy is frequently indicated in patients with prolonged mechanical ventilation, so intubation time may be a confounding factor when relating tracheostomy with the development of VAP.

No association was found between any of the chronic diseases introduced in the model and the development of VAP. Nor was an association found with surgical interventions at the thoracic and abdominal level or with age, unlike some investigations in which these variables were found to increase the risk of VAP.[viii,xiv,xv,xx,xxx]

The cases and controls underwent surgical procedures in similar proportions, which is why this variable was not significant in any of the analyses performed; and with regard to age and chronic diseases, the reason for not finding an association could also be found in the high proportion of patients with trauma among the cases, who tend to be young and with few chronic diseases.[xxviii]

We found no significant association between the Glasgow Coma Scale and risk of VAP, contrary to the findings of other researchers;[xxvi,xxviii] although in this study it was only possible to evaluate a small group of the total number of patients included. The microorganisms isolated in the cases, mainly *A. baumani, K. pneumonia* and *P. aeruginosa*, have been described in other studies as the cause not only of VAP but also of other HAIs.[v,x,xxxiv] The proportion of bacterial resistance in late VAP was higher than in early VAP, which is congruent with what has been described in the literature on the subject in which late VAP is associated with multidrug-resistant microorganisms.[x,xiv,xxx] The clinical characteristics of the cases were also within those described in previous studies.[vii,x]

The limitations to carrying out the study were the lack of an adequate order of the notes in some clinical records, and the difficulty in understanding the handwriting in the clinical histories, evolution notes and indication sheets. In addition, there could be errors in the recording of the information. Since a sample was calculated for the three hospitals, it was not possible to make an individualized analysis per hospital, and due to the study type, the ability to extrapolate the data on isolates and antimicrobial resistance is limited.

It is recommended to minimize intubation time, evaluate the possibility of extubation on a daily basis and create protocols for extubation, with the aim of preventing VAP.[v] There are strategies and protocols such as the use of bundles that aim to facilitate the prevention of VAP and other HAIs, measures such as handwashing before handling the airway, minimizing sedation, adequate oral hygiene, raising the back of the hospital bed by 30 to 45 degrees and continuous staff training are useful in all patients undergoing ventilation.[xxxv,xxxvi]

Additionally, in trauma patients, pain management, the use of spirometers and physiotherapy can be useful to accelerate extubation and avoid reintubation.[xxxvii]

Conclusion

Leukocytosis and fever were the most frequent clinical findings in VAP cases. The most frequently isolated microorganisms in patients with VAP were *A. baumani*, *K. pneumonia* and *P. aeruginosa*. Male gender, history of trauma and days of intubation are risk factors for ventilator-associated pneumonia in tertiary hospitals in El Salvador.

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