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Original Research Article

Role of APACHE-II Score in Predicting The Incidence of Ventilator-Associated Pneumonia in Intensive Care Unit Patients

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Abstract: *A prevalent nosocomial infection in the intensive care unit (ICU) is ventilator-associated pneumonia (VAP). VAP is defined as pneumonia in individuals with invasive mechanical ventilation during the preceding 48 hours; it affects 5–40% of patients with invasive mechanical ventilation. These scoring systems forecast the mortality, hence the disease's prognosis, which is very important in limited health resources and an increased cost of health management. ICU staff and doctors are highly recommended to be familiar with using the APACHE-II scoring system. The three main components of the APACHE-II score are Acute Physiology scores (APS), age scores, and chronic health scores, generating a score from 0 to 71. These 12 measurements are measured within 24 hours of ICU admission. APACHE-II shows a better prediction of hospital outcomes than SAPS-II. So, the APACHE-II score can be used as an ICU standard. A study by Sutiono et al. in Indonesia stated that an APACHE-II score greater than 15 is linked with a higher risk of VAP.* ***Objective:*** *To see the APACHE-II score's role in predicting ventilator-associated pneumonia incidence.* ***Methods:*** *This is a retrospective Cross-sectional Study done at the surgical ICU of Doctors Hospital and Medical Centre, Lahore, Pakistan, during the 18 months from 1st January 2022 to 30th June 2023. After the Approval to conduct this study was obtained from the hospital's ethical committee (can be presented on request), data were collected manually and filled in tables in a Microsoft Office Word Document. Data was presented in the form of frequency (Percentages). Exclusion criteria for this study were patients aged less than 16 years, with a stay of less than 24 hours, and those who did not have all 19 physiological parameters. All patients over 16 years who stayed in the ICU for more than 24 hours were included in this study.* ***Results:*** *293 patients were put on mechanical ventilation in the Surgical I.C.U. of Doctors Hospital and Medical Centre over the study period. Out of these 293 patients who were put on mechanical ventilation, 46 (15.69%) patients developed ventilator-associated pneumonia (VAP). Of 46 patients, 31 (67.4%) survived, and 15 (32.6%) expired. The prevalence of micro-organisms causing VAP is as follows: Pseudomonas 11(23.9%), Klebsiella 10 (21.7%), Acinetobacter 9 (19.5%), Candida albicans 6 (13%), Burkholderia 3 (6.5%), Staphylococcus 3 (6.5%), E. coli 2 (4.34%), Proteus mirabilis 1 (2.2%) and Enterobacter cloacae 1 (2.2%). Patients are then divided into two groups (those with APACHE-II score <20 and those with APACHE-II Score >20) to see the correlation between APACHE-II and VAP incidence. Patients with APACHE-II scores of more than 20 are 90 (30.7%), and 203 patients have less than 20. Of the group with APACHE Score <20, 18 (8.86%) developed VAP, and of the group with APACHE-II Score >20, 28 patients (31%) had developed VAP.* ***Conclusion: The*** *APACHE-II Scoring system is a good predictor of Ventilator-associated Pneumonia in intensive care unit settings. An APACHE-II score of more than 20 is a higher risk of developing ventilator-associated pneumonia than patients with an APACHE-II score of less than 20.*

Keywords: Ventilator Associated Pneumonia (VAP), Intensive Care Unit (ICU), Mechanical Ventilation, Microbiological Culture, VAP Care Bundle, APACHE-II

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Introduction

A prevalent nosocomial infection in the intensive care unit (ICU) is ventilator-associated pneumonia (VAP). VAP is defined as pneumonia in individuals who have invasive mechanical ventilation during the preceding 48 hours; it affects 5–40% of patients who had invasive mechanical ventilation (1,2,3).

Significantly, the presence of an endotracheal tube compromises the body's natural defenses, the cough reflexes of the larynx and glottis, which prevent microaspiration around the tube's cuff and thereby increase the risk of ventilator-associated pneumonia (VAP). The ventilator's positive pressure is constantly pushing this bacterium-enriched material forward. Nosocomial infections are only the tip of the iceberg regarding the immunosuppression and decreased phagocytosis that critical illness patients may exhibit (4). VAP puts financial strain not only on families but also on the health system of developing countries by increasing the duration of ICU stay and medications.

Age, incorrect initial therapy, mechanical breathing duration, hospital stay length, comorbidities, and invasive procedures are some of the risk variables shown to increase the likelihood of patient fatality in VAP studies. (5,6,7) . A practical scoring method is necessary for clinical usage since the criteria for evaluating these risk variables differ among research and cannot be directly transferred to real-world scenarios. There are currently only a handful of validated scoring systems for VAP mortality risk prediction; they include the APACHE II. (8).

Clinical scoring systems classify the risk, predict health outcomes, and enhance other clinical activities. There is no specific agreed classification of these predicting scores (9). These scoring systems forecast the mortality, hence the disease's prognosis, which is very important in limited health resources and an increased cost of health management (10). ICU staff and doctors are highly recommended to be familiar with using the APACHE-II scoring system (11). The three main components of the APACHE-II score are Acute Physiology scores (APS), age scores, and chronic health scores, generating scores from 0 to 71 (12). These 12 measurements are measured within 24 hours of ICU admission. APACHE-II shows a better prediction of hospital outcomes than SAPS-II (13). So. APACHE-II score can be used as an ICU standard. A study by Sutiono et al. in Indonesia stated that APACHE-II scores greater than 15 are linked with a higher risk of VAP (14).

The rationale behind conducting this study in our hospital is to see the correlation between APCHE-II and VAP incidence in our Surgical ICU. Not much literature is available regarding a specific cut point of APACHE-II and VAP incidence. The limitation of our study is its retrospective nature.

Methodology

This is a retrospective Cross-sectional Study done at the surgical ICU of Doctors Hospital and Medical Centre, Lahore, Pakistan, during the 18 months from 1st January 2022 to 30th June 2023. Measuring variables include demographics of the patients (Age, Gender, etc.), APACHE-II score calculated at the time of admission, length of ICU stay, and mortality rate and VAP incidence

A data collection Excel spreadsheet was prepared to summarise the information from each patient record, including the calculated APACHE-II score during the first 24 hours of ICU admission, the day of admission, and the day of patient discharge or expiry. The range of APACHE-II score is from 0-71. Points of 25 or less show a mortality of 50%, and the APACHE-II score of 35 or more shows a mortality of 80%. After the approval to conduct this study was obtained from the hospital's ethical committee (can be presented on request), data were collected manually and filled in tables in a Microsoft Office Word document. Data was presented in the form of frequency (Percentages). Exclusion criteria for this study were patients aged less than 16 years, with more extended stays than 24 hours, and those who did not have all 19 physiological parameters. All patients aged more than 16 years and who stayed in ICU for more than 24 hours were included in this study.

Results

Over the study period, two hundred ninety-three patients were put on mechanical ventilation in the Surgical I.C.U. of Doctors Hospital and Medical Centre. Out of the 293 patients, 104 (35.49%) patients had APACHE-II scores between 3-10, 99 (33.7%) patients had APACHE-II scores between 11-20, 67 (22.8%) patients had scores between 21-39, 18 (6.14%) patients had a score between 30-40 and 5 (1.7%) patients had APACHE-II score more than 40 (see table 1). The mean APACHE-II score is 14.42. Out of these 293 patients who were put on mechanical ventilation, 46 (15.69%) patients developed ventilator-associated pneumonia (VAP). Of these 46 patients, 31(67.3%) were males and 15 (32.6%) were females. Out of these 46 patients, 11(23.69%) patients have an age <40 years, 12 (30.4%) have an age between 40-60 years, and 21 (45.6%) patients have an age >60 years (see table 2). Of 46 patients, 31 (67.4%) survived, and 15 (32.6%) expired. The prevalence of micro-organisms causing VAP is as follows: Pseudomonas 11(23.9%), Klebsiella 10 (21.7%), Acinetobacter 9 (19.5%), Candida albicans 6 (13%), Burkholderia 3 (6.5%), Staphylococcus 3 (6.5%), E. coli 2 (4.34%), Proteus mirabilis 1 (2.2%) and Enterobacter cloacae 1 (2.2%) (figure 1).

Patients are then divided into two groups (those with APACHE-II score <20 and those with APACHE-II Score >20) to see the correlation between APACHE-II and VAP incidence. Patients with APACHE-II scores of more than 20 are 90 (30.7%), and 203 patients have less than 20. Of the group with APACHE Score <20, 18 (8.86%) developed VAP, and of the group with APACHE-II Score >20, 28 patients (31%) had developed VAP (see Table 3).

The only gram-positive organism is Staphylococcus aureus, and it is 100% sensitive to vancomycin, levofloxacin, linezolid, teicoplanin, rifampicin, doxycycline, and minocycline, while 66.6% sensitive to gentamicin and chloramphenicol. Almost all gram-negative organisms were sensitive to colistin except one E. coli. All Pseudomonas and Acinetobacter isolates resisted carbapenems (100% resistance). In comparison, Klebsiella is only 40% (4 out of 10) sensitive to carbapenems, E. coli 50% (1 out of 2), Burkholderia 66.6% (2 out of 3) and Proteus mirabilis was 100% sensitive. Klebsiella is 70% sensitive to chloramphenicol. Minocycline has 100% susceptibility for Acinetobacter, Enterobacter, and Staphylococcus aureus, while 60% susceptibility to Klebsiella and 33.3% for Burkholderia. Levofloxacin has a sensitivity of 45.4% for Pseudomonas, 40% for Klebsiella, and 0% for Acinetobacter. Antibiotic susceptibilities are shown in Table 4.

Table 1: details of Apache-ii scoring of ICU patients and the difference between actual and predicted mortality

APACHE-II Score	Number of patients	Predicted Mortality	Observed Mortality	Difference in mortality
3-10	104 (35.49%)	7.7%	3.7%	4
11-20	99 (33.7%)	19.3%	14%	5.3
21-30	67(22.8%)	45.2%	53.2%	-8
31-40	18 (6.14%)	76.73%	73.68%	3.05
>40	5(1.7%)	85.2%	66%	19.2

Table 2: Details of patients who had ventilator-associated pneumonia, demographics, isolates, incidence, and fate of patients

Characteristics	Features	Early-onset VAP	Late-onset VAP	Total Positive VAP.
Total cases of VAP	Classification of VAP	13 (28.26%)	33 (71.7%)	46 (15.69%)
Gender	Male	9(69.2%)	22(66.6%)	31(67.3%)
	Female	4(30.7%)	11(33.3%)	15(32.6%)
Mean Age	<40 years	3(23.07%)	8(24.2%)	11(23.9%)
	40-60 years	5(38.4%)	9(27.2%)	14(30.4%)
	>60 years	5(38.4%)	16(48.4%)	21(45.6%)
Isolates in Tracheal Cultures	Staphylococcus Aureus	0	3(9.09%)	3(6.5%)
	Pseudomonas aeruginosa	4(30.7%)	7(21.2%)	11(23.9%)
	Klebsiella pneumonia	2(15.38%)	8(24.2%)	10(21.7%)
	Acinetobacter species	1(7.69%)	8(24.2%)	9(19.5%)
	E. coli	1(7.69%)	1(3.03%)	2(4.34%)
	Burkholderia cepacia	1(7.69%)	2(6.06%)	3(6.52%)
	Proteus mirabilis	0	1(3.03%)	1(2.2%)
	Candida albicans	4(30.7%)	2(6.06%)	6(13.0%)
	Enterobacter cloacae	0	1(3.03%)	1(2.2%)
Outcome of VAP	Survived	6(46.1%)	25(75.7%)	31(67.4%)
	Died	7(53.8%)	8(24.2%)	15(32.6%)

Table 3: Showing the correlation of APACHE-II score and Ventilator-associated pneumonia

APACHE-II SCORE	N (%)	Ventilator-Associated Pneumonia	N (%)
>20	90 (30.7%)	Yes	28 (31%)
		No	62 (68.8%)
<20	203 (69.3%)	Yes	18(8.86%)
		No	185 (91.13%)

Table**: Showing antibiotic susceptibility of the isolates obtained from tracheal culture**

Antibiotics	Staph aureus	Klebsiella pneumoniae	Pseudomonas aeruginosa	Acinetobacter species	E. Coli	Burkholderia cepacia	Proteus mirabilis	Enterobacter cloacae
Meropenem	-	S(4/10)40%	0%	0%	S(1) 50%	S(2)66.6%	S(1) 100%	S(1) 100%
Imipenum	-	S(4/10)40%	0%	0%	0%	0%	S(1) 100%	S(1) 100%
Piperacillin-tazobactem	-	S(4) 40%	0%	0%	0%	0%	S(1) 100%	S(1) 100%
Vanvancomycin	S (3/3)100%	-	-	-	-	-	-	-
Ceftazidime	-	S(1)10%	S(2) 18.1%	-	-	S(1)33.3%	S(1) 100%	-
Amikacin	-	S(4) 40%	S(4) 36.3%	-	S(1) 50%	-	S(1) 100%	S(1) 100%
Tobramycin	-	S(4) 40%	S(4) 36.3%	S(1) 11.1%	-	-	S(1) 100%	S(1) 100%
Amoxicillin-Clavulanate	-	S(3)30%	-	-	-	-	S(1) 100%	-
Cefipime	-	-	S(2)18.1%	-	-	-	-	S(1) 100%
Collection	-	S (10)100%	S (11)100%	S (9)100%	S(1) 50%	N/A	S(0/1) 0%	S(1) 100%
Chloramphenicol	S(2/3) 66.6%	S(7)70%	-	-	S(1) 50%	1/3 (33.3%)	-	S(1) 100%
Levofloxacin	S(1/3) 33.3%	S(4)40%	S(5)45.4%	0%	-	S (2)66.6%	-	S(1) 100%
Ofloxacin	-	S(4) 40%	S(5)45.4%	-	-	-	-	S(1) 100%
Ciprofloxacin’	-	S(4) 40%	S(2)18.1%	S(6)66.6%	-	S(1)33.3%	-	S(1) 100%
Doxycycline	S(3/3) 100%	S(6)60%	-	S(9)100%	-	-	S(1) 100%	S(1) 100%
Minocycline	S(3/3) 100%	S(6)60%	-	S(1)11.1%	-	-	-	S(1) 100%
Gentamicin	S(2/3)66.6%	S(4)40%	-	-	-	-	-	-
Lineolid	S (3/3)100%	-	-	-	0%	0%	0%	-
Teicoplanin	S(3/3) 100%	-	0%	0%	-	-	-	0%
RIFAMPICIN	S(3/3)100%	0%	-	-	-	-	-	-
Trimethoprim/sulfamethoxazole	S(1/3) 33.3%	-	-	-	-	-	-	-

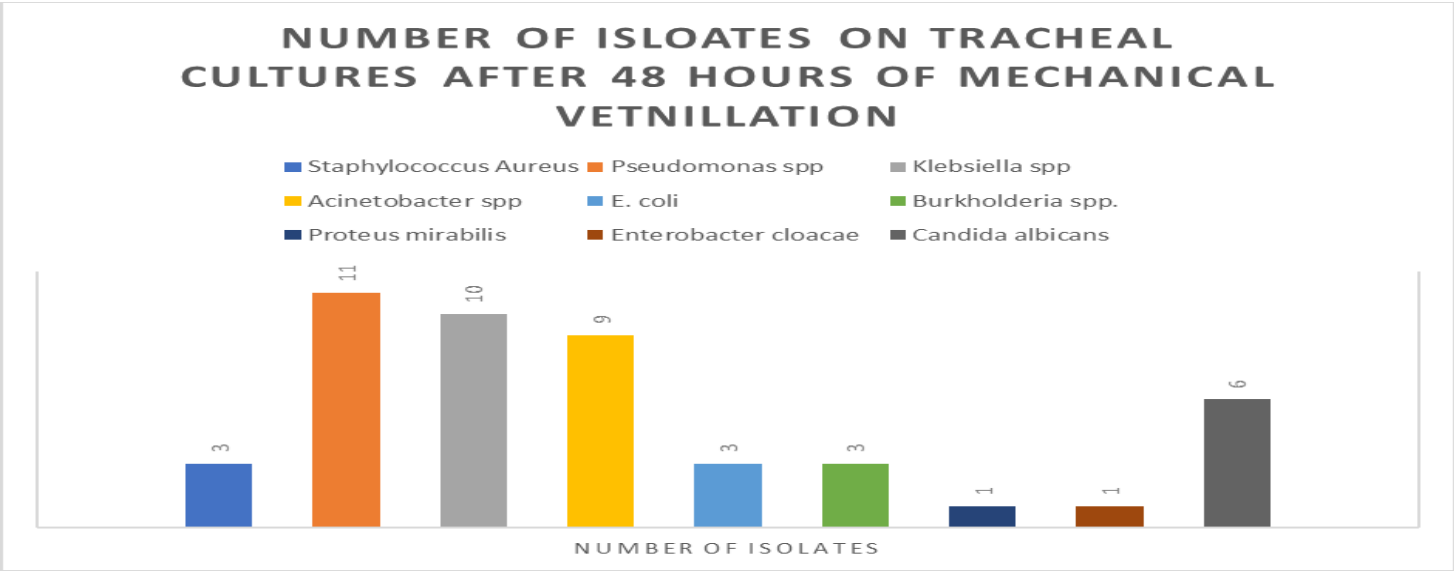

Figure 1: Showing isolates obtained from tracheal cultures of patients who had developed VAP

Discussion

APACHE 2 score plays a significant role in determining the risk of developing VAP in mechanically ventilated patients in the ICU. The risk of VAP was higher in our study in patients with higher APACHE 2 Scores. Out of 293 patients whose APACHE 2 scores were calculated,203 had APACHE 2 Scores less than 20(69.3%), of which 18 (8.86%) developed VAP. Ninety patients had APACHE 2 scores greater than 20(30.7%). Out of them, 28 patients (31%) developed VAP. The results are similar to a study by Mustafa et al. in April 2012, and Panwar et al., which also showed that patients with higher APACHE 2 scores in the first 24 hours risk developing VAP(15,16).

The mean APACHE 2 score was 14.42%, comparable to 10.7 and 16.5 in the United States of America and 14.2 in New Zealand (24).

The cumulative incidence of VAP is 15.69% in our study, which correlates with a study done by Deborah et al. (17) and Yaseen et al. (18).

In our study, 67.3% of included patients were males, while 32.6% were females. This male predominance may be secondary to more males admitted to our surgical ICU overall, and secondly, because there is a component in the X-chromosome that provides immunity to the female population. Male gender is an independent risk factor for VAP (19). This gender distribution in our study correlates with a study done by Sharpe et al. (20), in which 79% of the study population was male gender.

Patients older than 60 comprised 45.6% of the patients included in our study. Age is an independent risk factor for VAP secondarily to reduced physiological functions, including decreased immunity, lung elasticity, cough reflex, etc. (21).

In our study, 170 patients have APACHE-II scores between 11-30 at the time of admission, which is similar to a survey done by Saeed et al(25), but there is a large number of patients (108 patients) in the first group (APACHE-II 3-10).

Overall mortality in our study is 21.6%, which is lower than a study by Melaku et al. (26). APACHE-II scores have a meaningful correlation with ICU mortality. In our research, there is more observed mortality than predicted mortality in group 3 (APACHE-II 20-30), which contradicts a study in Hong Kong (27). All other groups have findings by Knaus et al. (28) and other available literature. So, there is a meaningful correlation between the APACHE-II score and the mortality risk in our study.

The average ICU stay is 4.3 days in our study, comparable to 4.2 days in a study done in Hong Kong (27)). ICU length of stay is an essential indicator of resource consumption in the ICU and puts a financial burden on the health sector.

Our study also showed that multi-drug resistant organisms were responsible mainly for both early and late-onset VAP irrespective of the duration of onset, and the most common organisms are Pseudomonas aeruginosa, Klebsiella pneumoniae, and Acinetobacter baumannii. This study correlates with the study done by Lakhal et al. in 2021(22).

Common causative organisms of this study include gram-negative bacteria (GNB) like Pseudomonas aeruginosa, Klebsiella pneumoniae, Acinetobacter species, E. Coli, and gram-positive bacteria (GPB) like Staphylococcus aureus. These findings correlate with the study done by Jones et al(23).In our study, among the 46 VAP patients, the most common organism identified was Pseudomonas aeuroginosa (n=11) 23.9%, followed by Klebsiella pneumoniae(n=10) 21.7%, Acinetobacter Baumanni (n=9) 19.5%, Burkholderia cepacia(n=3) 6.5%, Staph Aureus(n=3) 6.5%, E. Coli(n=2) 4.3%, Proteus mirabilis(n=1) 2.2%, Enterobacter cloacae (n=1) 2.2% and Candida albicans(n=6) 13%. So among the organisms causing VAP, GNB (bacteria)constitute 80.3%, (GPB) gram-positive bacteria constitute about 6.5%, and the rest, 13%, is caused by Candida albicans. This trend correlates with a study by ALI et al., in which 74% of organisms are gram-negative and 20%-gram positive (23).

This study shows that APACHE-II has significant effectiveness in predicting the risk of VAP, mortality risk, and length of ICU stay of patients so that treatment triage, ICU care, and other decisions can be made accordingly. Moreover, it also signifies the importance of implementing VAP CARE BUNDLE and the empirical start of broad-spectrum antibiotics, especially against MDR-Gram harmful organisms in patients with high APACHE 2 scoring in the first 24 hours of admission.

The limitations of this study include its retrospective nature and its being a single-centre study.

Conclusion

APACHE-II Scoring system is a good predictor of Ventilator-associated Pneumonia in the intensive care unit settings. An APACHE-II score of more than 20 is at higher risk of developing ventilator-associated pneumonia than patients with an APACHE-II score of less than 20.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-SMCT-0885-24)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

SUR, US (Anaesthesia Trainee)

Manuscript drafting, Study Design, Study Design, manuscript review, critical input.

AA, MM (Anaesthesia Trainee)

Review of Literature, Data entry, Data analysis, and drafting article.

SG (Anaesthesia Trainee)

Conception of Study, Development of Research Methodology Design,

ER

Data collection

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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