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Comparison of APACHE II, MPM and CPIS Scoring Systems with Regard to Determine of Mortality at Ventilator-Associated Pneumonia

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Authors' contributions

This work was carried out in collaboration between all authors. Author HS designed the study, wrote the protocol, wrote the first draft of the manuscript and approved finial submission. Authors IS, SS, ES, TE, AM and IO managed the literature searches, analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Ventilator-associated pneumonia (VAP) due to mechanical ventilation is an important issue that increases mortality and cost of treatment. In this study, we aimed to compare the effectiveness of three scoring models for estimation of mortality and morbidity in patients with ventilator associated pneumonia.
Study Design: Prospective research.
Place and Duration of Study: Patients with VAP who were admitted into intensive care unit Pamukkale University Hospital prospectively included in the study between January 2012 and June 2012.
Methodology: Demographical data, diagnosis on admission, departments from where admitted, APACHE II, Mortality Probability Model II_0 ($MPMII_0$) and Mortality Probability Model II_{24} ($MPMII_{24}$) scores on admission, length of stay in intensive care and hospital, duration of mechanical

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ventilation, microbiological data for pneumonia, outcome and Clinical Pulmonary Infection Score values on day 1, 3, 5 and 7 were recorded.
Results: Eighty patients (F/M: 37/43) were included study. Mortality was 67.5%. MPM II_0, MPMII_{24} values were significantly high in patients who has died but ROC curves were not significant for any of the scoring systems. In addition, relationship between scoring models and mortality, duration of mechanical ventilation, length of stay in intensive care and hospital was not statistically significant (*P*=.05).
Conclusion: We concluded that each of the three scoring systems for the prediction of mortality in VAP was not superior to each other.

Keywords: Ventilator-associated pneumonia; mortality probability model II; APACHE II; clinical pulmonary infection score.

1. INTRODUCTION

Patients who have admitted intensive care unit (ICU) have concomitant diseases and invasive interventions that increase morbidity and mortality. Therefore, various scoring models have been developed to estimate prognosis and to direct the treatment [1]. While most of them are intended to general population, some of them were developed for subgroups of patients.

Ventilator associated pneumonia (VAP) due to mechanical ventilation is an important issue that increase mortality and cost of the treatment [2]. It is thought that VAP is an important variable for decreasing of mortality, in a condition in which VAP was eliminated. However, Esperatti et al. [3] reported that there were no significant difference between VAP and pneumonia unallied with mechanical ventilation.

Development of scoring system for diagnosis and prognosis of VAP has been an interesting research area for clinicians. Clinical pulmonary infection score (CPIS) was first described by Pugin et al. [4] to aid in VAP diagnosis by combining clinical and radiological findings with laboratory investigations. However, there are trials that question suitability of CPIS model, though it is usually used [2,5-7].

Therefore, we hypothesized that general prognostic models are successful for estimating mortality at VAP and it is not necessary to develop a special model. In this study, we aimed to compare CPIS with usually performed prognostic models, Acute Physiology and Chronic Health Evaluation (APACHE II) and Mortality Probability Model (MPM II).

2. MATERIALS AND METHODS

Patients with VAP who were admitted into intensive care unit Pamukkale University Hospital prospectively included in the study between January 2012 and June 2012. The study comprised 80 patients older than 18 years treated in ICU for at least 24 hours. Patients with a history of coronary artery surgery or a major burn, recipients of organ transplants, and patients referred from other ICUs were excluded from the study. Moreover, only the first data set of patients with a history of twice or more admittance in ICU was included in data analysis.

Demographical data (age, weight, gender), diagnosis on admission, concomitant disease and clinical services from which the patients were taken, were recorded. APACHE II, MPM II_0 and MPM II_{24} scores were calculated at ICU admission. CPIS scores were calculated according to six variables (temperature, white blood cells, secretions, oxygenation, chest X ray, sputum culture) (Table 1) and recorded on day 1, 3, 5 and 7. Ventilator-associated pneumonia was defined according to guidelines of The American Thoracic Society and The Infectious Diseases Society of America. Length of stay in ICU, length of stay in hospital, length of mechanical ventilation, outcome of treatment (excitation, referral to another clinic, or discharge) and microbiological factors of VAP were recorded.

2.1 Statistical Analysis

Statistical analyses of data were performed by using programme of Statistical Package for the Social Sciences (SPSS) 16.0. The distribution of normality was tested by the Kolmogorov-Smirnov Z test and the homogeneity of the variances was tested both with the Levene and Welch test. Results are expressed as mean, standard deviation (SD), median (minimum-maximum) or numbers of occurrences. Parametric data were analyzed by the Independent samples t test and non parametric data were analyzed by the Mann-Whitney U test. Logistic regression test was

performed for the relationship between variables and the outcome. The obtained scoring data with all scoring systems were standardized by normal distribution curve in 0-1 probability intervals. Receiver operating characteristic (ROC) curve was used to determine a cut-off value for mortality and sensitivity and specificity of each scoring system for prediction of mortality. *P*<0.05 was accepted as the level of statistically significance.

3. RESULTS AND DISCUSSION

Eighty patients were included into study (46.3% female, n=37; 53.8% male, n=43). Mean of age was 67.4±16.68 (range: 19-95) and mean of weight was 69.2±14.1 (range: 40-105). There was no significant difference between survivors and exitus, with respect to demographical data (P=.05, Table 2).

When the outcome was evaluated, 26 patients were found to be discharged from the ICU (32.5%) and 54 died (67,5%) in this period. Mean of duration of mechanical ventilation was 34.2±27.4 and means of LOS in ICU and hospital were 36.2±27.8 and 39.4±28.5, respectively.

Diagnosis on admission were lung cancer (n=4, 5.0%), cardiac diseases (n=18, 22.5%), postoperative diseases (n=13, 16.25%), neurological diseases (n=17, 21.25%), hematological diseases (n=4, 5.0%), genitourinary diseases (n=7, 8.75%), respiratory diseases (n=14, 17.5%) and other (n=3, 3.75%). Most of the patients were referred from emergency department (n= 39, 48.8%) and others were admitted from operating room (n=11, 13.8%), clinical services (n=28, 35.0%), other hospitals (n=2, 2.5%). Microbiological factors of VAP were gram negative bacillus (*Pseudomonas aeruginosa, Klebsiella pneumonia*, n=30, 37.5%), nonfermentative gram negative bacillus (*Acinetobacter baumannii, Stenotrophomonas maltophilia*, n=30, 37.5%), gram positive cocci (*Staphylococcus aureus, Streptococcus pneumonia*) and enterobacteriaceae (n=14, 17.5%) and others (*Candida albicans,* n=6, 7.5%). There were no significant differences between died and survivor patients according to diagnosis on admission, microbiological factors of VAP (Table 3). However, the mortality rate was significantly lower in patients referred from other clinics (11.8%) than those referred from the emergency department (*P*=.04).

There were no significant differences between exitus and survivor patients for APACHE II and CPIS scores on day 1, 3, 5 and 7 (p>0.05). MPM II_0 ve MPM II_{24} scores of exitus patients were significantly higher than the survivor ones (*P*<.05, Table 2). In addition, the differences of duration of mechanical ventilation, length of stay (LOS) in ICU and hospital were not statistically significant (*P* =.05, Table 4). Relationship between estimation of mortality rate, duration of mechanical ventilation, LOS in ICU and hospital and scoring models was not statistically significant (Table 4).

Table 1. Clinical pulmonary infection score

Day	Parameter	Value for score of	
		1 point	2 points
1	Temp (ºC)	38.5 to 38.9	≥39 or ≤36
	White blood cells/mm^3	<4,000 or >11,000	<4,000 or >11,000 and ≥50% bands
	Secretions	Nonpurulent	Purulent
	PaO_2/FiO_2		≤240 and no ARDS
	Chest X-ray infiltrates	Diffuse or patchy	Localized
3	Temp (ºC)	38.5 to 38.9	≥39 or ≤36
	White blood cells/mm^3	<4,000 or >11,000	<4,000 or >11,000 and ≥50% bands
	Secretions	Nonpurulent	Purulent
	PaO_2/FiO_2		≤240 and no ARDS
	Chest X-ray infiltrates	Diffuse or patchy	Localized
	Progression of chest X-ray infiltrates		Yes (no ARDS or congestive heart failure)
	Sputum	Culture >1+	Culture >1+ and same organism on Gram staining

ARDS: Acute Respiratory Distress Syndrome. PaO2: partial pressure of arterial oxygen, FiO2: fraction of inspired oxygen

Table 2. Demographical data, scores and outcome of patients

		Exitus (n=54) N(%)	Survivors (n=26) N(%)	*P*
Gender	Female	26(48%)	11(42%)	.624
	Male	28(52%)	15(58%)	
		Mean±SD	**Mean±SD**	
Age (years)		69.3±14.1	63.3±20.8	.168
Weight (kg)		70.8±13.8	66.0±14.5	.081
APACHE II score		27.815±5.962	25.500±6.370	.116
MPM II_0 score		0.831±1.389	0.146±1.230	.035
MPM II_{24} score		0.487±1.518	-0.252±1.364	.039
CPIS (day 1)		6.574±0.944	6.462±0.811	.603
CPIS (day 3)		5.148±1.053	4.769±1.107	.142
CPIS (day 5)		3.611±1.309	3.346±0.977	.363
CPIS (day 7)		2.926±1.211	2.500±0.906	.116
Duration of MV		28.56±20.20	45.96±36.04	.105
LOS in ICU		28.93±20.36	66.00±94.89	.059
LOS in hospital		31.98±20.70	69.35±94.81	.058

MV: mechanical ventilation, LOS: lenght of stay, ICU: intensive care unit.

Table 3. Effects of diagnosis, prior clinical departments and microbiological factors of VAP to mortality rate

	Ex-n (%)	Survivor-n (%)	*P*
Diagnosis			
Postoperative	10(18.6)	3(11.5)	**1.00**
Lung cancer	4(7.4)	0(0)	
Neurological disease	6(11.1)	11(42.3)	
Cardiac disease	15(27.6)	3(11.5)	
Hematological disease	3(5.6)	1(3.8)	
Genitourinary system disease	4(7.4)	3(11.5)	
Respiratory disease	10(16.7)	4(15.4)	
Other disease	2(3.7)	1(3.8)	
Service from			
Emergency department	23(42.6)	16(61.5)	**.04**
Operating theater	8(14.8)	3(11.5)	
Clinical services	23(42.6)	5(19.2)	
Other hospitals	0(0)	2(7.7)	
VAP factors			
Gram (-) bacillus	19(35.2)	11(42.3)	**.557**
Gram (+) cocci	8(14.8)	6(23.1)	
Nonfermentative Gram (-) bacillus	22(40.7)	8(30.8)	
Other	5(9.3)	1(3.8)	

ROC curve was not significant for getting a cutoff point with respect to estimation of mortality (Figs. 1 and 2). The values of area under curve of the scoring models were between 0.537 and 0.648 and estimation of mortality was poor for each models.

4. DISCUSSION

While APACHE and MPM scoring models are general prognostic, CPIS were developed for diagnosis of VAP [4]. However, CPIS has been used for different purposes; diagnosis [6,8-16], estimation of mortality [9,17,18-21] and LOS in ICU or hospital [19-21] and also determination of antibiotic therapy [22,23]. Patel et al. [6], Tejerina et al. [8] and Schurink et al. [9] have advocated that usage for diagnostic purpose was not reliable. Bregeon et al. [10] have found that CPIS had sensitivity and specifity (93% and 85%, respectively) for diagnosis of VAP in a postmortem study. However, we used CPIS

model for estimation of morbidity and mortality. We defined VAP according to guidelines of The American Thoracic Society and The Infectious Diseases Society of America [24].

CPIS doesn't have full appropriate properties for a prognostic model. Because it also includes variables (microbiological data) which can't be got easily [25]. Although the microbiological variables are usually used [15], Rea-Neto et al. [14] found that those data have not contributed to diagnosis of VAP. However, Lauzier et al. [16] showed that CPIS has had limited feasibility when the results of microbiological culture have been ignored. In our study, we used the microbiological culture of tracheal aspirate. We calculated the scores at the original time for each models, because we tried to observe feasibility of initial forms.

CPIS model has been performed at different populations: trauma [6], pediatric [26], brain injury [27], medical ICU [11] and surgical ICU (7). We observed the mix (medical-surgical) ICU patients in contrast to these trials.

Six points is usually accepted as threshold for CPIS [12,19]. Sachdev et al. [26] observed that CPIS>8 points was correlated with the outcome in pediatric population. Sensitivity of CPIS has ranged from 60% to 89% and specificity of CPIS has ranged from 43% to 59% for level of CPIS>6 points [11,15,17]. Schurink et al. [9] found sensitivity as 83% and specificity 17% for CPIS>5 points. In our study, ROC curve was not significant to determine a cut off value in our mix ICU patients.

Gursel et al. [17] demonstrated that discrimination of APACHE II was better than CPIS and SOFA and APACHE II>16 was an independent predictor of mortality. Huang et al. [18] showed that APACHE II >27 (not CPIS) was an independent and early predictor of mortality. Kollef et al. [20] also concluded APACHE II was more valuable than CPIS. However,

Table 4. Relationship between scores and MV duration, LOS in ICU and hospital

	Scores	***P***
Length of stay in hospital	APACHE II	0.966
	MPM_0	0.482
	MPM_{24}	0.811
	CPIS (day 1)	0.488
	CPIS (day 3)	0.872
	CPIS (day 5)	0.836
	CPIS (day 7)	0.655
Length of stay in intensive care unit	APACHE II	0.888
	MPM_0	0.397
	MPM_{24}	0.846
	CPIS (day 1)	0.417
	CPIS (day 3)	0.822
	CPIS (day 5)	0.863
	CPIS (day 7)	0.708
Duration of mechanical ventilation	APACHE II	0.861
	MPM_0	0.370
	MPM_{24}	0.833
	CPIS (day 1)	0.399
	CPIS (day 3)	0.818
	CPIS (day 5)	0.932
	CPIS (day 7)	0.794
Mortality	APACHE II	0.315
	MPM_0	0.534
	MPM_{24}	0.902
	CPIS (day 1)	0.199
	CPIS (day 3)	0.176
	CPIS (day 5)	0.557
	CPIS (day 7)	0.258

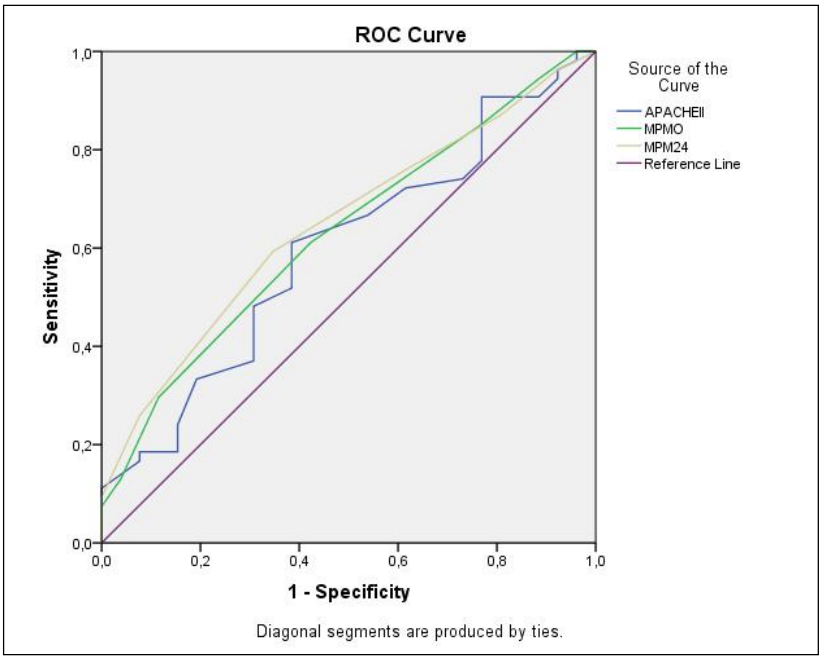

Fig. 1. Specificity and sensitivity of APACHE II, MPM0 and MPM24 for estimation of mortality

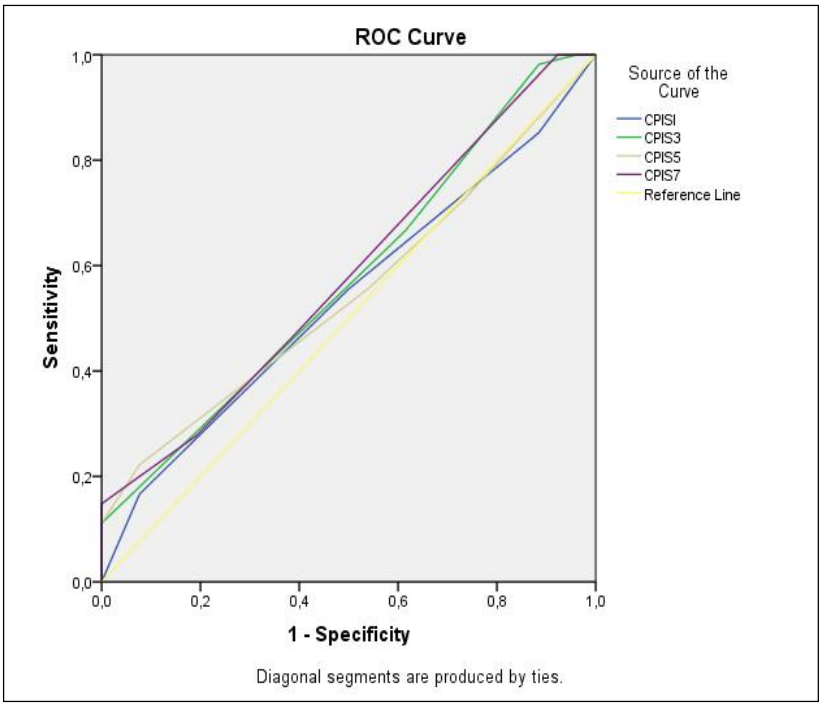

Fig. 2. Specificity and sensitivity of CPIS for estimation of mortality

Ntoumenopoulos et al. [21] found neither APACHE II nor CPIS were successful models. In our study, none of the scoring models (MPM II, APACHE II and CPIS) was superior to another. In addition, this result didn't change for serial measurements of CPIS. According to Gursel et al. [17] this was the expected result, because CPIS had been developed for diagnosis of VAP.

The result of our study was similar with Ntoumenopoulos et al. [21].

Yang et al. [19] found positive correlation between CPIS model and duration of mechanical ventilation, LOS in ICU and hospital. Xiao-Yu Zhou et al. [28] reported that APACHE II is useful for predicting 30-day mortality in patients with VAP, but that the CPIS does not have good discrimination and calibration for predicting mortality in mechanically ventilated intensive care patients. However, we could not find a relationship of CPIS with those parameters. The single use of the Clinical pulmonary infection score is questionable but it may be useful as a monitoring issue and in combination with diagnostic approach [29].

5. CONCLUSION

In conclusion, MPM II_0 and MPM II_{24} scores were significantly higher in died patients. However, none of the scoring models showed significant relationship with mortality, duration of mechanical ventilation, LOS in ICU and hospital in subgroup of ICU patients with VAP.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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