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ORIGINAL ARTICLE

Comparison of the accuracy of two scoring systems in predicting the outcome of organophosphate intoxicated patients admitted to intensive care unit (ICU)

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KEYWORDS

Organophosphate poisoning;
Mortality prediction;
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Abstract *Introduction:* Organophosphates(OP) are one of the most common causes of poisoning, especially in developing countries, with high morbidity and mortality. As mortality rate of OP poisoning is still high, early diagnosis and appropriate treatment is often life saving. OP is the main cause of poisoning and death in the poison control centre (PCC), Ain Shams University (ASU) in Egypt.

Objective: To compare the accuracy of acute physiology and chronic health evaluation score (APACHE IV) and simplified acute physiology score (SAPS II) in the prediction of mortality of patients with organophosphate poisoning (OPP) who required admission to the Intensive Care Unit (ICU) of PCC of ASU between January 1st, 2009 and December 31st, 2009.

Methods: A prospective study conducted by collecting data on consecutive patients with acute OPP admitted to the intensive care unit over 12 months. Data required to calculate the patients' predicted mortality by (APACHE) IV and (SAPS) II scoring systems were collected.

Results: Ninety patients were recruited in the study with acute OP toxicity. The observed mortality following acute OP toxicity was 13.3% (12 patients). The area under the receiver operator

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characteristic (ROC) curves of APACHE IV score was better than SAPS II score (0.921 ± 0.054 SE, 0.807 ± 0.078 SE, respectively). APACHE IV and SAPS II scores were significantly higher in the non-survival than in the survival group ($P < 0.05$).

Conclusion: APACHE IV and SAPS II scores calculated within the first 24 h are good prognostic indicators among patients with acute OP toxicity that required ICU admission with preference to APACHE IV score. APACHE IV and SAPS II scores above 89, 44, respectively within the first 24 h are a predictor of poor outcome in patients with acute OP toxicity.

Recommendation: Application of APACHE IV and SAPS II scores is a good predictor of high mortality in OP intoxicated patients which helps in proper allocation of resources.

1. Introduction

Organophosphates (OP) are used as insecticides in agricultural and domestic settings throughout the world.[1] Poisoning with OP compounds is responsible for great morbidity and mortality in developing countries. According to the World Health Organization, 1 million serious accidental and 2 million suicidal poisonings with insecticides occur worldwide every year, and of these, approximately 200,000 die, mostly in developing countries.[2]

In 2005 statistical analysis of the acutely poisoned patients received by PCC, Ain Shams University, revealed that insecticide intoxication represents 49% of the total number of chemical poisoning, organophosphorous insecticides account for 55% of insecticide poisoned cases (2201cases). One-hundred and forty four OP patients required intensive care unit "ICU" admission, out of them 28 patients had died.[3]

OPs inhibit the enzymes acetyl cholinesterase (AChE) in cholinergic synapses and on red cells and butyryl cholinesterase in plasma. As a result of this enzyme inhibition, the substrate acetylcholine accumulates. The continued stimulation of the acetylcholine receptor accounts for the clinical signs and symptoms of OP poisoning.[1]

Scoring systems have been continuously developed to predict outcomes in patients with severe illness, to improve resource allocation and to assist in clinical decision-making particularly for intensive care unit (ICU) patients.[4] Acute physiology and chronic health evaluation II (APACHE II) and simplified acute physiology score II (SAPS II)[5] are two representative systems currently in wide use for measuring the condition of individual ICU patients.[6]

A variety of scoring systems have been used to quantify the severity of illness of patients admitted to the intensive care unit (ICU) and to predict their chances of survival to ICU and hospital discharge.[7] Such prognostic scoring systems include the simplified acute physiology score (SAPS), the mortality probability model, and the acute physiology and chronic health evaluation (APACHE) scoring system. The APACHE was introduced in the early 1980s, and, although minor modifications have been made over the years, only three major revisions have occurred. The APACHE IV was published in May 2006.[8]

Prognostic systems have been used to justify the development of progressive care units by identification of a group of ICU patients at low risk for mortality.[9] Such systems may also provide objective assessment for the development of ICU discharge criteria and may identify those patients likely to require ICU readmission.[7]

The aim of the present study was to compare the accuracy of the APACHE IV and SAPS II scoring system patients admitted to the ICU.

2. Methods

The present study was a prospective analysis conducted between January 1st, 2009 and December 31st, 2009 on all patients with acute organophosphate poison admitted to the Intensive Care Unit (ICU) of Poison Control Center (PCC) of Ain Shams University Hospital.

Patients of both sexes with acute organophosphate poisoning were recruited in the study. The diagnosis of organophosphate poisoning was based on the presence of history of exposure to an OP agent, clinical manifestations of OP poisoning, clinical response of signs and symptoms after administration of atropine and low serum pseudo cholinesterase activity.[10]

Patients are excluded if they were younger than 16 years of age, died within four hours of admission to ICU or stayed in the ICU less than 24 h. All patients received standard medical treatment under the direction of the hospitals' consultant physicians. This followed a standard protocol, which was dictated by the patient's clinical condition and was independent of the character of the OP involved.

All data was collected concurrently for consecutive ICU admissions. Data included sociodemographic data by history taking as age, sex, occupation and residence and poisoning data as type of OP insecticide, the mode of poisoning, route of exposure, time elapsed between acute OP exposure and admission and date of discharge from ICU and hospital.

The APACHE IV and SAPS II scores were calculated in accordance with the original methodology, using the worst physiologic values in the first ICU day.

The APACHE IV score is made up of the acute physiology score (APS), age and admission circumstances, totaling 142 variables of which 115 are admission diagnoses. The APS was based on the most abnormal values registered during the first 24 h after ICU admission (such as blood pressure, body temperature, heart rate, etc.).[8]

The SAPS II includes only 17 variables: 12 physiology variables, age, type of admission (scheduled surgical, unscheduled surgical, or medical), and three underlying disease variables (acquired immunodeficiency syndrome, metastatic cancer, and hematologic malignancy).[5]

Pseudocholinesterase was determined using a kinetic colorimetric method according to Waber, 1966[11] with reference range: 1900–3800 U/l.

All patients were followed until discharge from the hospital or death. Data were analyzed by SPSS software package for statistical analysis Version 16.0 (SPSS Inc., Chicago, IL, USA) for Windows and (MedCalc statistical, Mariakerke, Belgium) software Version 11.0.

Data will be presented as mean ± SD, when indicated. Student's *t* test was used to compare normally distributed continuous variables. The Pearson Chi-Square test was used for determination of the relationships between group (survivors and non survivors) and categorical variables; the Mann Whitney *U*-test was used for determination of difference between two groups about continuous data which have non-normal distribution. *P*-value less than 0.05 was considered statistically significant.

The ability and accuracy of the models for hospital mortality prediction were determined by examining their discrimination and calibrations. Discrimination power was assessed by the area under the Receiver Operating Characteristic (ROC) curve[12] and calibration by standardized mortality ratio (SMR). SMR was calculated to observe the difference between expected and actual mortality rates as being calculated by dividing observed hospital mortality by the predicted hospital mortality. An AUC of >0.9 was considered to be outstanding, >0.8–0.9 excellent, 0.7 to 0.8 acceptable, and <0.7 was considered poor.[13]

The study was conducted after the approval of the research ethics committee of faculty of medicine, Suez Canal University.

3. Results

Ninety (40 male and 50 female) patients with acute OP poisoning were recruited during the study period according to inclusion criteria; with age range of 16–55 years and admitted to ICU. The mortality rate was 13.3% (12/90). The major route of exposure to OP in these patients was by ingestion. APACHE IV and SAPS II scores were calculated for all 90 patients and compared.

Regarding the residence of the patients and their relation to the actual survival, Fig. 1 shows that the majority of patients was from urban areas (56 patients); of them 80.3% survived and 19.7% had fatal outcome. The remaining 34 patients were from rural areas, 33 (97%) of them survived and only one (3%) did not survive. There was significant difference between survival and non-survival groups according to their residence as ($P < 0.05$).

Regarding the occupation of the patients, Table 1 shows that acute organophosphate intoxication occurred more frequently in unemployed (27.8%) followed by housewives (23.3%), manual workers (15.6%), civil employer (12.2%), farmers (12.2%), and the lowest incidence was among students (8.9%). There was a significant difference between survival and non-survival groups according to their occupation ($P < 0.05$).

Concerning the types of OP compound used in poisoning, Table 2 shows that in most of patients, 57 (63.4%) the type of OPC used could not be identified and all of them were survived, while malathion poisoning was identified in 30 patients (33.3%) and 12 (13.3%) of them did not survive. Only three patients (3.3%) were known to be poisoned by dimethoate and all of them survived. There is significant difference between survival and non-survival groups according to the types of used OP compound ($P < 0.05$).

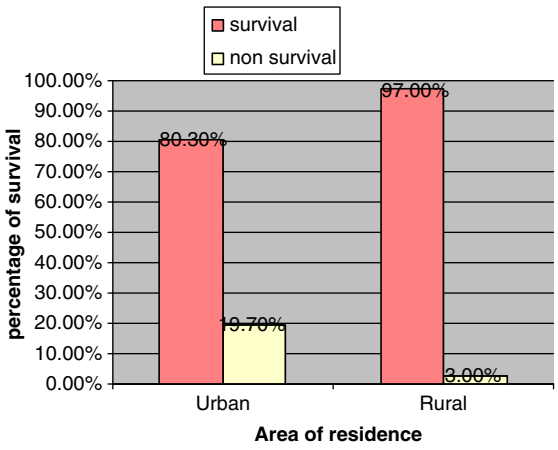

Figure 1 The relationship between the residence and the actual survival among the recruited 90 patients with acute organophosphate poisoning.

Regarding the relationship between actual survival and predicted mortality by APACHE IV score and SAPS II score according to their best cutoff point, Table 3 shows that 19 (21%) patients were predicted to die by APACHE IV score and 9 (10%) of them were predicted to die by SAPS II score and actually 11 (12%) patients died, and 71 (78.9%) patients were predicted to live by APACHE IV score out of them 4 (4.4%) patients only who were predicted to die by SAPS II score and actually only 1 (1.1%) patient died. There is no significant difference between actual survival and non survival patients according to patients SAPS II scores predicted mortality and their APACHE IV scores predicted mortality ($P > 0.05$).

Fig. 2 shows the comparison between the ROC curves of the two models "APACHE IV and SAPS II" which were plotted to estimate the discriminative power of the models by the area under the ROC curve. The values were (0.921) (standard error 0.0549) for APACHE IV and (0.807) (standard error 0.0787) for SAPS II. The area for SAPS II, although very good but it was less than the area for APACHE IV by (0.114). When SAPS II and APACHE IV curves were compared, we found a statistically significant difference (one-sided test, $P < 0.001$) between the two methods.

The cut-off values, sensitivities, specificities of scoring systems and the area under the ROC curve are shown in Table 4. An APACHE IV score of (89) or higher was predictive of mortality as determined by its ROC curve, with (93.59%) sensitivity and (91.67%) specificity ($P < 0.001$). A SAPS II score of (44) or higher was predictive of mortality as determined by its ROC curve, with (85.90%) sensitivity and (75%) specificity ($P < 0.001$). The area under the curve for APACHE IV is the largest, and there is statistically significant difference when compared with SAPS II ($P < 0.05$).

The actual, predicted and standardized mortality rates are shown in Table 5. The actual mortality in OPP was (13.3%) (12/90). Predicted mortality rates were (21.1%) and (23.3%) for APACHE IV and SAPS II, respectively. Predicted mortality determined by APACHE IV and SAPS II scoring systems was not significantly different from actual mortality. SMR and 95% CI for APACHE IV was 0.63 (0.53–0.71) and for SAPS II 0.57 (0.46–0.66) ($P < 0.05$). There was a significant

Table 1 The relationship between the occupation and the actual survival among the recruited 90 patients with acute organophosphate poisoning.

		Observed survival		Total
		Survival	Non survival	
Occupation				
Unemployed	No	17	8	25
	%	18.9%	8.9%	27.8%
Student	No	8	0	8
	%	8.9%	0%	8.9%
Housewife	No	19	2	21
	%	21.1%	2.2%	23.3%
Farmer	No	11	0	11
	%	12.2%	0%	12.2%
Civil employer	No	11	0	11
	%	12.2%	0%	12.2%
Manual worker	No	12	2	14
	%	13.3%	2.2%	15.6%
Total	No	78	12	90
	%	86.7%	13.3%	100.0%

X^2: 12.429, $P < 0.05$.

Table 2 Types of OP compound used in poisoning in relation to the actual survival "as recognized by history taking".

		Actual survival		Total
		Survival	Non survival	
Type of OPC				
Unknown	No	57	0	57
	%	63.3%	0%	63.3%
Malathion	No	18	12	30
	%	20.0%	13.3%	33.3%
Dimethoate	No	3	0	3
	%	3.3%	0%	3.3%
Total	No	78	12	90
	%	86.7%	13.3%	100.0%

X^2: 27.69, $P < 0.05$.

Table 3 Comparison between actual survival and predicted mortality by APACHE IV and SAPS II score.

APACHE IV score predicted mortality				Actual survival		Total
				Survival	Non survival	
Non survival[a]	SAPS II score predicted mortality	Non survival	No	8	9	17
			%	42.1%	47.4%	89.5%
		Survival	No	0	2	2
			%	0%	10.5%	10.5%
	Total		No	8	11	19
			%	42.1%	57.9%	100.0%
Survival[b]	SAPS II score predicted mortality	Non survival	No	4	0	4
			%	5.6%	0%	5.6%
		Survival	No	66	1	67
			%	93.0%	1.4%	94.4%
	Total		No	70	1	71
			%	98.6%	1.4%	100.0%

[a] *X2*: 1.626, P > 0.05.
[b] *X2*: 0.061, P > 0.05.

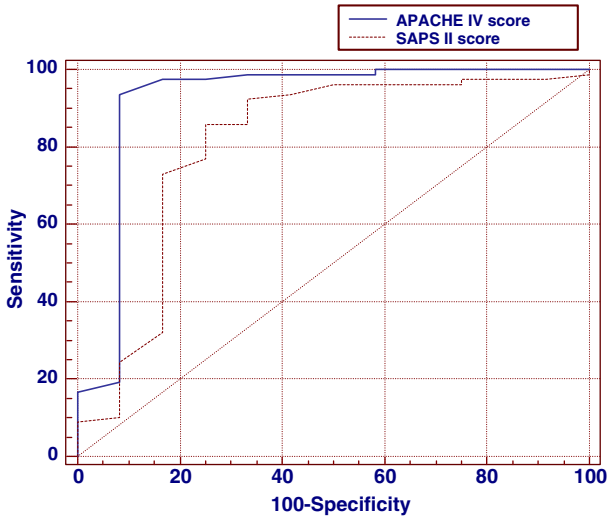

Figure 2 Receiver operating characteristic ROC curves for SAPS II and APACHE IV. The relationship between true positives *Sensitivity* and false positives *100 minus specificity,* is shown for both models.

difference in predicted mortality rates by APACHE IV, SAPS II scores and actual mortality rates as to SMR ($P < 0.05$).

4. Discussion

Organophosphate poisoning is a health problem in developing countries and may be associated with mortality and morbidity.[14,15]

The provision of critical care services consumes a large amount of financial and human resources and has come under scrutiny.[16] The identification of those who will require prolonged ICU stay or who may be suitable for intermediate (rather than intensive) care may help with the optimal use of limited resources.[17]

Large ICU patient datasets and prognostic scoring systems based on them are a valuable part of outcomes research in critical care.[7] Although prognostic scoring systems have been used to predict the outcome of groups of ICU patients, the use of a scoring system for prognostication of individual patient outcomes is fraught with difficulty and is controversial.[18]

Two models for predicting outcome in ICU patients have been evaluated in this study. The two models were developed from large heterogeneous cohorts of medical and surgical patients and it is important to evaluate their predictive accuracy in a smaller setting with a different disease spectrum before applying them to make quality of care assessments.

The most commonly affected age group in the current study ranged from 18 to 30 years, this finding was similar to those recognized by Vander-Hoek et al., (1998)[19] and Sudakin et al., (2000).[20] And also as stated by Sungur and Guven, 2001[21] that the mean age was 30 ± 15 years when admitted to the medical intensive care unit of a 600-bed university hospital. This may be attributed to the proposed fact that suicidal ideation commonly arises out of two wishes: to escape from the problems of life and to get revenge on others. These thoughts and feelings have been termed "transformation drives", which explain the conditions faced by this age group who begins to deal with problems of life.

In this study females were more exposed to OP insecticides than males (1.2:1), not the same was reported by Leveridge, (1998)[22] and Duran and Collie, (2000).[23] These results may be attributed to the stressful conditions experienced by these females in their life. These differences could be interpreted that, men and women respond differently to stress biochemically. Men are more prone to react to stressful situations with raised blood pressure, while women reacted with an increase in heart rate and aggressive behaviors against others or against themselves.[24]

In the present study, the majority of cases came from urban areas; the same result was reported by Thomas et al. (2002). Other studies in developing countries showed that OP insecticides are common suicidal agents among adolescents especially in urban areas.[25]

In the present study a quarter of cases were unemployed, followed by housewives then manual workers, farmers, civil employer and lastly students**.** Saadeh et al. (1996)[26] found that unemployed constituted 43% of the patients with OPC poisoning.

The stressful environment in urban areas with the increasing percentage of unemployment issue could explain the highest incidence of poisoning in urban areas among unemployed males.[27]

In the present study, the type of OPC was unknown in the majority of cases. Malathion was the OP involved in toxicity in the remaining cases except three who were poisoned with dimethoate. This was in agreement with reports by Verhulst et al. (2002)[28] and Godhwani et al. (2004),[29] and this could be attributed to the fact that Malathion is widely available and is used as insecticides in agriculture as well as for household purposes and many OPC in the market are unknown or not registered or licensed.

Table 5 Mortalities predicted by the two scoring systems.

	Actual mortality (%)	Predicted mortality (%)	SMR*	95% CI*
APACHE IV	13.3	21.1	0.63	0.53–0.71
SAPS II	13.3	23.3	0.57	0.46–0.66

X^2: 5.107, $P < 0.05$.
* SMR, standardized mortality ratio. CI, confidence interval.

Table 4 Classification table for the scoring systems.

	Best cut-off point	Sensitivity (%)	Specificity (%)	ROC area
APACHE IV	89	93.59 (85.7–97.9)	91.67 (61.5–99.8)	0.921 (0.845–0.967)
SAPS II	44	85.90 (76.2–92.7)	75.00 (42.8–94.5)	0.807 (0.710–0.882)

ROC: Receiver Operating Characteristics.
Figures in parentheses are 95% confidence interval.

The present study shows that the actual mortality in OPP was 13.3%. Predicted mortality rates were 21.1% and 23.3% for APACHE IV and SAPS II, respectively.

Our study is in agreement with that of Tugsan et al. (2006) who stated that the actual mortality in OPP was 21.9%. Predicted mortality by all systems was not significantly different from actual mortality [SMR and 95% CI for GCS: 1.00 (0.65–1.35), APACHE II: 0.87 (0.54–1.03), SAPS II: 1.40 (0.98–1.82)]. The area under the ROC curve for APACHE II was largest, but there was no statistically significant difference when compared with SAPS II and GCS (GCS 0.9009/0.059, APACHE II 0.9299/0.045 and SAPS II 0.8919/0.057).[30]

The estimates of overall mortality following OPP ranges from 20% to 25% as found by Abdollahi et al. (1997)[31] and Yamashita et al. (1997)[32] and the mortality in mechanically ventilated patients ranges from 13% to 50% as found by Yen et al. (2000).[33] These reports consider the delay in discovery and transport, insufficient respiratory management, aspiration pneumonia, and sepsis as attributes to the cause of death in most cases.

In our study, to estimate the discriminative power of the models, we used the area under the ROC curve. The values were 0.807 (standard error 0.078) for SAPS II, 0.921 (standard error 0.054) for APACHE IV. The area for SAPS II, although very good, is lower than the area of the original SAPS II model (0.823). APACHE IV is more accurate than SAPS II score.

Our results are in agreement to what found by Moreno et al. (1997)[34] in that to estimate the discriminative power of the models, they used the area under the ROC curve. Moreno et al., found that the values were 0.817 (standard error 0.015) for SAPS II, 0.782 (0.016) for APACHE II. The area for SAPS II, although very good, was lower than the area of the original SAPS II model (0.823).[34] But our results differ from them in that when SAPS II and APACHE II curves were compared, we found a statistically significant difference (one-sided test, $P < 0.001$) between the two methods).

Regarding the standardized mortality ratios, our study showed that although the standardized mortality ratios were less than 1, potentially indicating optimal ICU performance, the 95% CIs were wide and included unity. The APACHE IV and SAPS II SMRs for all patients admitted to the ICU during the period of the study were 0.63 (0.53–0.71) and 0.57 (0.46–0.66), respectively.

In spite of some limitations, we were able to obtain some helpful findings when assessing hospital mortality using APACHE IV and SAPS II in ICU patients. First, there was a significant increase in observed mortality when APACHE IV or SAPS II scores increased. Both systems, however, overestimated mortality. The SMR was significantly below 1.0 in both scoring groups. An SMR below 1.0 may have at least three different explanations: selection of less severe patients, good clinical performance, or error of the system itself. Second, calibration and discrimination was good for both systems. Correlation between the APACHE IV and SAPS II was excellent, but this is not surprising, given the overlap in the variables considered.

Although the ideal scoring system has yet to be developed and no system has ever been demonstrated to be completely reliable, the ongoing improvement of existing systems should no doubt continue.

It may be of benefit to combine the more general scores with one or several organ dysfunction scores to determine the extent of functional impairment of specific organs.

5. Conclusion

Both APACHE IV and SAPS II score systems can be used to approximately predict in-hospital mortality of ICU patients with preference to APACHE IV score.

Further studies are needed to develop prognosticating scoring systems to help in risk stratification of these patients and APACHE IV would be a useful tool for such studies.

6. Conflict of interest statement

None declared.

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