The Accuracy Comparison of Scoring Systems in the Outcome Prediction of Acute Organophosphate Poisoning

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Abstract:	**Background**: Organophosphates (OP) with high morbidity and mortality are one of the most common causes of poisoning especially in developing countries. Early diagnosis and appropriate treatment is often life saving as mortality rate of OP poisoning is still high. The objective of this study is to compare the accuracy of scoring systems (the sequential organ failure assessment (SOFA) score, acute physiology and chronic health evaluation II (APACHE II) score and glasgow coma scale (GCS)) in the prediction of mortality of acute organophosphate poisoning. **Methodology:** A retrospective and prospective study was done on 200 patients with acute OP poisoning admitted to the Poison Control Center (PCC), hospitals of Ain Shams University in the period between 1/1/2016 and 31/12/2016. Information was collected from the sheets and computerized data base of the patients. SOFA score, APACHE II score and GCS were calculated to each patient admitted. The results were revised, coded and organized for statistical analysis. **Results:** The study results revealed 180 (90%) patients recovered and 20 (10%) patients died. The area under the curve of receiver operator characteristic (ROC) of SOFA score was 0.995, for APACHE II score was 0.986 and compared to GCS was 0.977 with significantly higher SOFA and APACHE II scores in the died patients than in the recovered patients (P <0.001). As regards GCS there was statistically significant difference between recovered and died patients (P <0.001). **Conclusion**: It could be concluded that SOFA score, APACHE II score and GCS systems can be used to predict mortality of acute organophosphate poisoning with preference to SOFA score which had the highest accuracy and predictive ability. From the previous results, our study recommends that application of SOFA score, APACHEII score and GCS are good predictors of high mortality in OP intoxicated patients which helps in proper allocation of resources particularly for intensive care unit patients.
Key words	Organophosphate, APACHE II score, SOFA score, Glasgow

Introduction

Organophosphates (OP) with high morbidity and mortality are one of the most common causes of poisoning especially in developing countries. Early diagnosis and appropriate treatment is often life saving as mortality rate of OP poisoning is still high (Rahimi et al., 2006).

Despite the great developments in the intensive care management, OP compounds ingestion is still a greatly contributing agent of poisoning with mortality rates 10-

20%. Since the mortality still represents high percentage, so estimation of the severity and prognosis of the patients intoxicated by these agents is important (Lee et al., 2013; Muley et al., 2014).

There is lack of validated scoring systems to determine the severity or predicting the outcome of acute OP poisoning with highly variable history and difficulty in determining the dose and specific OP compound ingested make predicting outcome for an

individual person inaccurate and potentially dangerous. Patients in good condition after admission can deteriorate rapidly and may need intubation with mechanical ventilation (Pore et al., 2011).

APACHE II system serves as a useful index for evaluation of the severity of poisoning due to multiple organ system involvement. And, SOFA score has been shown to have a good correlation between predicted and observed patient outcome (Williams and Gannon2009; Mahrous et al., 2011 and Kim et al., 2013). The GCS is the most widely used scale to describe the level of consciousness of the patient and is reliable for assessment and prognosis of non-traumatic coma patients (Deshpande et al., 2012; Moussa et al., 2018).

Aim of the work

The work aim is to compare APACHE II score, SOFA score and GCS accuracies in predicting the outcome of acute organophosphate poisoning.

Methodology

A retrospective and prospective study was done on 200 patients with acute OP poisoning admitted to PCC in hospitals of Ain Shams University in the period between 1/1/2016 and 31/12/2016. An approval from the Ethical Committee and the permission of the director of PCC were taken. Information was collected from the sheets and computerized data base of the patients with the confidentiality of these records, an informed consent has been obtained from each case.

Patient᾿s Selection Criteria:

The selected patients were of both sexes with acute OP exposure. The OP poisoning diagnosis was based on history of exposure to OP compounds, toxidrome characteristic to OP toxicity, improvement of muscarinic symptoms and signs after atropine administration and low serum pseudo-cholinestrase activity (Lee, 2001)

Exclusion Criteria:

- Patients with history of sever cardiac, pulmonary, renal impairment or nephritic syndrome.
- Patients with any of the following which reduce pseudocholinestrase activity (e.g Parenchymal liver disease, acute infection, metastatic carcinoma, dermatomyositis, early pregnancy and Patients taking toxicants like carbon disulfide, cocaine and solanines or drugs like birth control pills.

The following data was collected from the sheet of each patient:

1. Sociodemographic data.
2. APACHE II score was calculated for each patient during the first 24 hours of stay by the standard methodology with range from 0 to 71 points. If a variable was measured more than once during that time, the worse value was used (Vincent and Moreno, 2010).

3. SOFA score was calculated for each patient by the standard methodology with range from 0 to 24 (Williams and Gannon, 2009).
4. GCS was measured on admission. The lowest score is 3 points and the highest score is 15 points (or 11 points with endotracheal intubation) (Mood et al., 2011).
5. Outcome of the patients:
   The patients were classified according to the outcome into recovered and died patients.

Statistical Analysis

The obtained results were revised, coded and organized for statistical analysis by SPSS. Mean and standard deviation was done for numerical data. Frequency and percentage were obtained for non-numerical data. Independent t-test was used to compare between groups of outcome. Linear regression analysis was used to identify significant predictors of outcomes. P-value was considered statistically significant if < 0.05. Standardized mortality ratio (SMR) was calculated by dividing observed hospital mortality by the predicted hospital mortality to observe the difference between expected and actual mortality rates. 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 curve of ROC curve and calibration by SMR. An area under the curve (AUC) of >0.9 was considered to be outstanding, if 0.8 to 0.9 was excellent, if 0.7 to 0.8 was acceptable, and was considered poor if < 0.7 (*Mahrous et al., 2011).*

Results

The total number of the patients was 200 patients of acute OP poisoning admitted to the Poison Control Center (PCC) in hospitals of Ain Shams University. Most of patients were belonging to teenager and middle age group (18 – 40 years) representing 44.5% of the patients in the study. Females affected more than males and patients from urban areas were more than rural areas. Acute organophosphate intoxication was found commonly occurring in unemployed (43%) followed by students (23%) and lastly housewives (12%) **(table, 1)**.

As shown in **table (2),** the outcome of the patients was as the following: 180 patients were recovered representing about (90%) and 20 patients were died representing about (10%). As regards hospital site admission, 57.5% of patients were in inpatient unit and 42.5% were in ICU. As regard complications developed, 24% of the patients in the present study developed complications.

Regarding the relationship between actual survival and predicted mortality by APACHE II score, SOFA score and GCS according to their best cutoff point, **table (3)** shows that 37(18.5%) patients were predicted to die by APACHE II score, 28(14%) of them were predicted to die by SOFA score and 22(11%)

patients were predicted to die by GCS. Actually 20(10%) patients died. There was significant statistical difference between recovered and died patients as regards GCS, APACHE II score and SOFA Score where patients who died had high values of APACHE II score, high values of SOFA Score and low values of GCS than recovered patients.

APACHEII score, SOFA score and GCS could be used as predictors of outcome of acute organophosphorus poisoning, (table, 4). As shown in table (5), the actual mortality rate was 10% and Predicted mortality rates were 18.5%, 14% and11% for APACHEII score, SOFA score and GCS, respectively.

SMR for APACHEII score was 0.54, for SOFA score 0.71 and for GCS was 0.90.

As shown in table (6) and figures (1, 2 and 3), APACHE II score at cut off value > 10 had corresponding sensitivity 100% and specificity 90.56% (P <0.001). On the other hand SOFA score at cut off > 5 had sensitivity 100% and specificity 90.56% (P <0.001) and GCS at cut off value ≤ 8 had sensitivity 85 % and specificity 97.22% (P <0.001). SOFA score had the largest AUC and there was statistically significant difference when compared with APACHE II score and GCS.

Table (1): Number and percentage of the studied patients as regard sociodemographic data (age, sex, residence and occupation)

Sociodemographic variables		Number	Percentage %
Residence	Urban	126	63%
	Rural	74	37%
Occupation	Unemployed	86	43%
	Student	46	23%
	Housewife	24	12%
	Civil employer	22	11%
	Manual worker	14	7%
	Farmer	8	4%

SD: Standard deviation

Table (2): Outcome, hospital site admission and complications developed of the studied patients in the present study.

Total number=200		Number	Percentage %
Outcome	Discharged	180	90%
	Died	20	10%
Hospital site admission	Inpatient	115	57.5%
	ICU	85	42.5%
Complications developed	Non complicated	152	76%
	Complicated	48	24%

ICU: intensive care unit

Table (3): Scoring systems of the studied patients in the present study.

	Discharged N= 180	Died N= 20	Total = 200	Independent t-test	
				t	P -value
APACHE II score					
≤ 10	163(90.6%)	0(0%)	163 (81.5%)	-15.45	<0.001
>10	17(9.4%)	20(100%)	37 (18.5%)		
Mean ±SD	4.58± 1.52	22.45± 7.61	6.37 ± 2.26		
Range	0 – 24	11 – 38	0 - 38		
SOFA score					
≤ 5	172(95.6%)	0(0%)	172(86%)	-21.39	<0.001
> 5	8(4.4%)	20 (100%)	28 (14%)		
Mean ±SD	1.41±0.57	10.75±2.46	2.34 ± 0.36		
Range	0 – 10	6 – 15	0 – 15		
GCS					
≤ 8	5(2.8%)	17(85%)	22(11%)	15.612	<0.001
> 8	175(97.2%)	3(15%)	178(89%)		
Mean ±SD	13.85± 2.29	5.20± 2.80	12.98 ± 3.50		
Range	6 – 15	3 – 10	3 – 15		

SD: Standard deviation

Table (4): Linear regression analysis of APACHEII score, SOFA score and GCS to detect predictors of outcome.

Linear regression analysis	Unstandardized C.		Standardized C.	P- value
	B	Standard Error	Beta	
APACHE II	-0.019	0.004	-0.461	**<0.001**
SOFA	0.101	0.007	1.192	**<0.001**
GCS	-0.062	0.004	-0.725	**<0.001**

C: Coefficients

Table (5): Actual mortality rate, predicted mortality rate and SMR of the scoring systems.

Model	Actual mortality rate	Predicted mortality rate	SMR
APACHE II	10%	18.5%	0.54
SOFA	10%	14%	0.71
GCS	10%	11%	0.90

SMR: standardized mortality ratio.

Table (6): The receiver operating characteristic curve of the scoring systems.

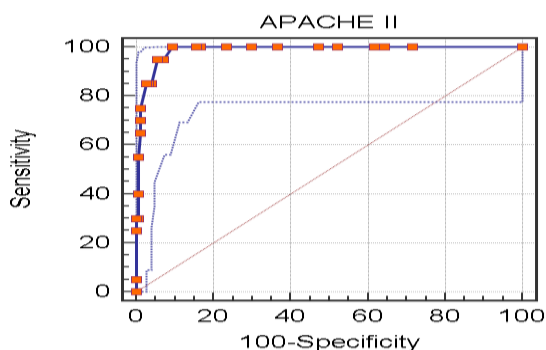| Variable	Cut off	AUC	Sensitivity	Specificity	Accuracy rate	95% CI
APACHE II score	>10	0.986	100	90.56	98.6%	0.97-1.00
SOFA score	>5	0.995	100	90.56	99.5%	0.98-1.00
GCS	≤8	0.977	85.00	97.22	97.7%	0.95-0.99

AUC: Area under the curve

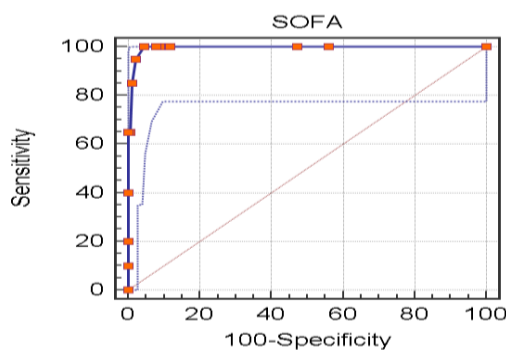**Figure (1): The ROC of APACHE II score.**

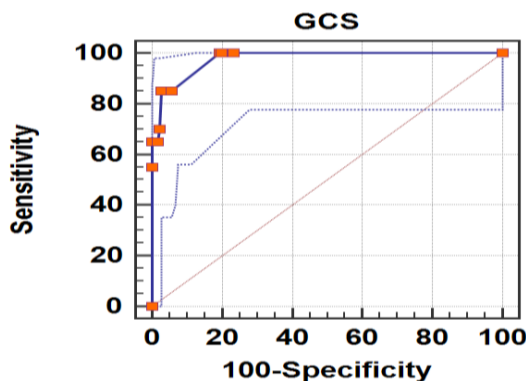**Figure (2): The ROC of SOFA score.**

Figure (3): The ROC of GCS

Discussion

Organophosphate poisoning is a health problem and may be associated with morbidity and mortality in developing countries.The aim of this study is to compare APACHE II score, SOFA score and GCS accuracies in the outcome prediction of acute organophosphate poisoning. In the current study 44.5% of patients were belonging to age from 18 to 40 years.

This finding was similar to that of *Ahmed et al., (2014)* and *Banday et al., (2015)* in which the incidence was highest in patients aged less than 40 years. There were only 2% of all patients in the study above 60 years old and this was in agreement with *Chintale et al., (2016)*.

This could be explained by the vulnerability to various emotional conflicts that can happen during this phase (teenager and middle age groups) of life in which the people are most ambitious and productive (*Banday et al., 2015*). In the current study females were more affected. This was in agreement with *Chaturvedi et al., (2014)* and *Gündüz et al., (2015) study* in which females were also affected more than males.

On contrary to many other studies males were more affected than females *(Muley et al., 2014; Sumathi et al., 2014; Ghaniger et al., 2016).*

Causes of female predominance in this study may be attributed to emotional liability of female to life stress and strains in our society than male. Also OP compounds are available in the home as a household product (*Z'gambo et al., 2016*).

In the current 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 *(Gunnell and Eddleston, 2003).*The reverse was reported by *Hassan and Madboly, (2013)* and *Bilal et al., (2014)* where most of patients came from rural areas. In the present study 43% of cases were unemployed followed by students then housewives. *Saadeh et al., (1996)* found that unemployment constituted 43% in patients with OP poisoning. On the other hand, in the study performed by *Rehiman et al., (2008)* house wives and students were the most common acutely organophosphate intoxicated patients. The present study showed that the actual mortality in OP poisoning was 10%. Predicted mortality rates were 18.5%, 14% and 11% for APACHEII score, SOFA score and GCS, respectively.

This was in agreement with results reported by *Bilal et al., (2014)* where death was observed in 10% cases. This ratio was close to this obtained by *Godhwani et al., (2004)* where it was 12%. *Yamashita et al., (1997)* reported a higher rate of 25%, while *Dharmani and Jaga, (2005)* reported that mortality of OP poisoning was 46%.

There was statistically significant association between high APACHEII score, high SOFA score and low GCS and severity of OP poisoning. This was in agreement with *Singh et al., (2011)* and *Kim et al., (2013)* studies in which non survivors had higher APACHE II score and SOFA score than survivors. Also, *Jabalameli et al., (2006)* reported that died patients had highest APACHE II Score and correlated with the occurrence of complications in OP poisoning.

These results also go with those of *Kang et al., (2009)* who reported that The APACHE II score was high in died patients in acute organophosphate poisoning and those who had complications especially respiratory failure. Also, this was similar to findings of *Vosylius et al., (2005)* who reported higher SOFA score in the non-survivors than the survivors and the development of more severe organ dysfunction was strongly associated with mortality. Also, *Budhathoki et al., (2009)* mentioned that GCS less than 8 had been more associated with mortality in children presenting with poisoning more frequently.

Moreover *Russell and Shobhan, (2009)* found that a GCS of 8 or less is a useful guide for the requirement of endotracheal intubation where the cause of coma is poisoning and *Muley et al., (2014)* mentioned that GCS ≤ 12 had been significantly associated with morbidity. By using linear regression analysis with the scoring systems studied in the current work it was found that APACHEII score, SOFA score and GCS were highly significantly increased with death hence could be used as predictors of outcome. This was similar to results of *Sam et al., (2009)* and *Sumathi et al., (2014).*

Kim et al., (2013) stated that SOFA score is significantly associated with mortality and has strong discriminative power for predicting mortality. APACHE II score is a simplified physiological score in prediction and assessment of the severity and mortality of OP poisoning and GCS can be applied in the prediction of the mortality in OP poisoning (*Sam et al., (2009).* Similarly, *Davies et al., (2008)* reported that GCS was effective at outcome prediction in acute organophosphate intoxication and patients presenting with a GCS ≤ 13 need intensive monitoring and treatment. SMR for APACHEII score was 0.54, for SOFA score 0.71 and for GCS was 0.90 and the AUC was 0.986 for APACHE II score, was 0.995 for SOFA score and compared to GCS was 0.977. Also, the accuracy rate of SOFA score (99.5%) was higher than that of APACHE II score (98.6%) and GCS (97.7%).

These results go with those of *Sumathi et al., (2014)* where the area under the curve was 0.896 for SOFA score and was 0.716 for APACHE II score and the accuracy rate of SOFA score was higher than that of APACHE II score. Also, *Bilgin et al., (2005)* found that the standardized mortality rates were 0.87 and 1.0 for APACHE II and GCS, respectively and AUC for APACHE II score was 0.93 and for GCS was 0.90. So all can predict the outcome of organophosphorus poisoning but SOFA score had the highest accuracy and

predictive ability followed by APACHE II score while GCS was the least one.

This was in agreement with *Baradari et al., (2016)* and *Shabir and Maqbool,(2017)* where their studies recorded that SOFA score is able to predict the outcome significantly. Also, *Kim et al., (2013)* concluded that SOFA score is more useful in predicting mortality, easier and simpler than APACHE II score.

Conclusion

SOFA score, APACHE II score and GCS systems can be used to predict in-hospital mortality of acutely organophosphate intoxicated patients with preference to SOFA score which had the highest accuracy and predictive ability.This helps in proper allocation of resources particularly for intensive care unit patients.

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الملخص العربي

مقارنة دقة أنظمة التسجيل فى التنبؤ بالنتيجة لمرضى التسمم الحاد بالمركبات الفسفورية العضوية

سهير على محمد و مروه أحمد حسب النبى¹ ومنى القطب موسى² و هانى محمد توفيق³ ومحمد عدلى⁴

مقدمة البحث: تعتبرالمركبات الفوسفورية العضوية من أهم اسباب حدوث التسمم الحاد وخاصة فى البلدان النامية كما انها مسئولة عن نسبه كبيرة من الحالات المرضية والوفيات. وحيث ان معدل الوفيات من التسمم الحاد بالمركبات الفسفورية العضوية مازال مرتفعا لذا فان التشخيص المبكر واستخدام العلاج المناسب دائما منقذين للحياه.

الهدف من الدراسة: تهدف هذة الدراسة الى مقارنة دقة أنظمة التسجيل سوفا واباتش الثانى ومقياس جلاسكو فى التنبؤ بحدوث الوفاة فى حالات التسمم الحاد بالمركبات الفسفورية العضوية.

طريقة البحث: تم عمل هذه الدراسة باثر رجعى ومستقبلى على ٢٠٠ مريض من حالات التسمم الحاد بالمركبات الفسفورية العضوية بمركز علاج التسمم بمستشفيات جامعة عين شمس فى الفترة ما بين ٢٠١٦/١/١ الى ٢٠١٦/١٢/٣١. وتم تقسيم المرضى الى مجموعتين رئيسيتين (حالات تم تحسنها و وفيات). وقد تم جمع البيانات من ملفات المرضى وقاعدة الملفات الالكترونية بالمركز والتى تشمل: تطبيق انظمة التسجيل سوفا واباتش الثانى ومقياس جلاسكو.

نتائج البحث: قد كشفت نتائج البحث ان ١٨٠ (٩٠٪) من المرضى تم تحسنهم و ٢٠ (١٠٪) من المرضى قد توفوا. وأظهرت الدراسة أيضا أن منطقة تحت منحنى خصائص المشغل المتلقى لنظام التسجيل سوفا كانت 0.995 ولنظام التسجيل اباتش الثانى كانت 0.986 مقارنة بمقياس جلاسكو التى كانت 0.977 وقد تبين من الدراسة ارتفاع انظمة التسجيل سوفا و اباتش الثانى فى الحالات التى توفيت عن الحالات التى تحسنت. كما أظهرت الدراسة فرق ذو دلالة إحصائية بين الحالات التى تم تحسنها والوفيات فيما يتعلق بمقياس جلاسكو.

استنتاج وتوصيات البحث: بناء على ذلك نستنتج انه من الممكن استخدام انظمة التسجيل سوفا واباتش الثانى ومقياس جلاسكو فى التنبؤ بحالات الوفيات داخل المستشفيات لمرضى التسمم الحاد بالمركبات الفسفورية العضوية مع تفضيل استخدام نظام التسجيل سوفا الذى يعتبر الاعلى من حيث الدقة والقدرة التنبؤية و توصى هذه الدراسة ان تطبيق أنظمة التسجيل سوفا و اباتش الثانى ومقياس جلاسكو يعتبر متنبأ هام لارتفاع معدل الوفيات لمرضى التسمم بالمركبات الفسفورية العضوية حيث يساعد ذلك على التخصيص الامثل للموارد خصوصًا لمرضى وحدة العناية المركِّزة.

١ قسم الطب الشرعي والسموم الإكلينيكية-كلية الطب -جامعة سوهاج – مصر.

٢ قسم الطب الشرعي والسموم الإكلينيكية-كلية الطب -جامعة عين شمس – مصر.

٣ مركز علاج التسمم مستشفيات جامعة عين شمس

٤ قسم الطب الشرعي والسموم الإكلينيكية-كلية الطب -جامعة مصر – مصر.