Prediction of the Outcome of Patients with Acute Hydrocarbons Poisoning using Poison Severity Scoring System; A Prospective Study

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Abstract: PURPOSE: Accidental hydrocarbons ingestion remains a serious contributor to childhood poisoning in low socioeconomic groups, with a high incidence of morbidity and occasional mortality. Hydrocarbon toxicities affect mainly the respiratory system and pulmonary pathology is the most serious complication. Although most children survive without complications or sequelae, some progress rapidly to respiratory failure and death. In this study, we aimed to investigate whether it was possible to predict outcome in hydrocarbons poisoning using a scoring system based on simple clinical parameters recorded solely on admission. METHODS: 100 patients with acute hydrocarbon toxicity consequently admitted to the Poisoning center will be subjected to full history taking, complete physical examination. Plain chest x-ray, ECG, ABG and routine blood investigations (CBC, Na, K, serum and Creatinine, AST and ALT) were done on admission. All patients were graded according to the Poison Severity Score (PSS) to either: None (0), Minor (1), Moderate (2), Severe (3) or Fatal (4). Their initial grading was correlated with their outcomes: Need for Intensive Care Unit admission, mechanical ventilation (MV) and the length of ICU and hospital stay as well as hospital mortality. RESULTS: 100% of the patients with grade (None=0) recovered completely and none was admitted to the ICU with a mean hospital stay of 1±0.0 day. 100% of the patients with grade (Minor=1) recovered completely and none was admitted to the ICU with a mean hospital stay of 1.26±0.44 days. 100% of the patients with grade 2 (Moderate) recovered completely. All of them were admitted to the ICU, 64.3% of them needed invasive mechanical ventilation and 35.7% did not. The mean hospital stay was 3.50±0.65 days and the mean ICU stay was 2.50±0.65 days. 25% of the patients with grade 3 (Severe) recovered completely and 75% died (hospital mortality). All of them were admitted to the ICU and needed invasive mechanical ventilation. Their mean hospital stay was 5.25±2.99 days and the mean ICU stay was 5±2.58 days. CONCLUSIONS: According to this study, the PSS could be a useful tool to predict outcome in patients admitted with hydrocarbon toxicity as the different grades of the PSS system had significant correlation with patients' outcome. Patients presenting with hydrocarbons with a PSS of ≥ 2 could be directly admitted to the ICU for possible need of MV because of associated unfavorable outcome.

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1. Introduction:

Hydrocarbons are organic substances that contain carbon and hydrogen; they are liquid at room temperature. All petroleum distillates (e.g., kerosene, gasoline, mineral seal oils, and naphtha) are hydrocarbons; however, not all hydrocarbons are petroleum distillates. Turpentine, for example, is a hydrocarbon made from pine oil. Hydrocarbons also often are mixed with agents that have systemic toxicity such as camphor, aniline dyes, heavy metals, and pesticides.[1]

Hydrocarbon ingestion accounts for two to three percent of non-pharmaceutical exposures in children younger than six years of age reported to US poison control centers.[2] In developing countries, studies suggest poisonings represent up to 2% of all pediatric hospital admissions and that kerosene aspiration may represent half of all poison admissions in the group less than five years of age. Admissions for hydrocarbon exposure were also longer than those for other poisonings .[3] Young children are at greatest risk of paraffin poisoning. Because paraffin has the consistency and appearance of water and in some places is stored in reused beverage containers without child-resistant caps, unsupervised children are at high risk of consuming it. Toxicity in adolescents often arises from inhalant abuse of hydrocarbons.[4-5]

Organ systems that can be affected by hydrocarbons include the pulmonary, neurologic, cardiac, gastrointestinal, hepatic, renal, dermatologic, and hematologic systems. The pulmonary system is the most commonly involved system.[6]

Pulmonary manifestations result from any degree of hydrocarbon aspiration, although their onset may be delayed for 12 to 24 hours. Immediate signs of aspiration include coughing, choking, gagging, and vomiting. Respiratory examination findings vary with the degree of pulmonary injury. Physical findings may include tachypnea, dyspnea, cyanosis, diminished resonance on percussion, suppressed or tubular breath sounds, and crackles. The radiographic findings of hydrocarbon aspiration often occur before the development of physical findings. They may be seen within 20 minutes or as late as 24 hours after aspiration.[7-9]

Cardiac arrhythmia also may occur after inhalation. Solvent hydrocarbons can sensitize the myocardium to catecholamines, leading to fatal arrhythmia ("sudden sniffing death").[10]Ingestion of aliphatic hydrocarbons causes direct local irritation to the pharynx, esophagus, stomach, and small intestine, with edema and mucosal ulceration Oro-gastric and intestinal irritation may be associated with nausea and hematemesis.[11] Hydrocarbon ingestion or inhalation may have direct CNS effects, including somnolence, headache, ataxia, dizziness, blurred vision, weakness, fatigue, lethargy, stupor, seizures, and coma. In addition, hypoxia caused by hydrocarbon aspiration may cause secondary CNS depression, including drowsiness, tremors, or convulsions.[10] Leukocytosis occurs early in the clinical course of hydrocarbon aspiration unrelated to pneumonitis and may last as long as one week. Hemolysis, hemoglobinuria, and consumptive coagulopathy also may occur with significant ingestion.[12]

In this study, the aim was to investigate whether it was possible to predict inpatient mortality in hydrocarbons poisoning using a scoring system based on simple clinical parameters and simple laboratory investigations recorded solely on admission.

Scoring systems have been used in clinical toxicology for many years. A standardized scheme for grading the severity of poisoning allows qualitative evaluation of the morbidity caused by poisoning, better identification of real risks, and comparability of data.[13]

Working from a simple grading proposed by the European Association of Poisons Centers and Clinical Toxicologists, a Poisoning Severity Score has been developed jointly with the International Programme on Chemical Safety and the European Commission. The Poisoning Severity Score has been elaborated, tested, and gradually revised during a project running 1991-1994. The Poisoning Severity Score grades severity as none (0), minor (1), moderate (2), severe (3), and fatal (4) poisoning. It is intended to be an overall evaluation of the case, taking into account the most severe clinical features.[13-14]

2. Patients and Methods

Patients

This study was conducted on 100 patients with acute hydrocarbons toxicity admitted to the Poisoning Center in the Alexandria Main University Hospital (AMUH). Patients were taken in consecutive order. All patients presented with recent history of intake or exposure to hydrocarbons (within the last 24 hours) was included in our study.

Exclusion criteria

Patients with history of central nervous system, cardiac, pulmonary or renal diseases and admission after 24 hours of exposure.

Methods

Patients with acute hydrocarbon toxicity admitted to the Poisoning center were subjected to full history taking, complete physical examination. The following measures were done for every patient included in the study on admission, every 24 hours and on discharge: Plain chest x-ray, Electrocardiogram (ECG) done by Cardimax (Fukuda Denish) and arterial blood gases (ABG) done by the blood gas analyzer GEM Primer 3500. Other laboratory investigations included: complete blood count (CBC) done by SYSMEX- KX21N, sodium (Na), potassium (K) (mEq/L) done by AVL 9180, blood urea nitrogen (BUN) & creatinine (mg/dL), Alanine aminotransferase (ALT) and aspartate aminotransferase [15] (IU/L) done by Hitachi 902.

The reference values for ABG parameters are as follows: pH (7.35-7.45), $PaCO_2$ (35-45), PaO_2 (70-100), HCO_3 (22-26), SaO_2 (90-95). The reference values for the CBC were: Hemoglobin (12-17 g/dL), Leukocytic count (4-10.5 k/µL) and platelet count (150.0 - 450.0 k/µL).

The reference values for these lab tests are as follows: Sodium (135-145 mEq/L), Potassium (3.5-5.2 mEq/L), BUN (7-20 mg/dL), Creatinine (0.5-1.4 mg/dL), ALT (<35 IU/L), AST (<35 IU/L).

An informed consent to participate in the study was taken from all the patients (if fully oriented) or from the relatives (if the patients were not oriented or younger than 18 years). The study was approved by the ethical committee of the faculty of Medicine, University of Alexandria.

All included patients were graded according to the Poison Severity Score (PSS)[13] to either:

NONE (0): No symptoms or signs related to poisoning.

MINOR (1): Mild, transient, and spontaneously resolving symptoms
MODERATE (2): Pronounced or prolonged symptoms
SEVERE (3): Severe or life-threatening symptoms.
FATAL(4): Death.

Applying the PSS, it took into account only the observed clinical symptoms and signs and did not estimate risks or hazards on the basis of parameters such as amounts ingested. The PSS was applied according to the most severe symptomatology.[13]

All patients received the standard treatment of hydrocarbon toxicity. Gastric emptying or lavage, administration of activated charcoal and induction of emesis were avoided for risk of aspiration. The patients' clothing was removed and their skin was cleaned to prevent continued inhalation exposure. Bronchospasm was treated with selective beta 2 agonists and corticosteroids. Pneumonitis caused by hydrocarbon aspiration was not treated routinely with antibiotics unless signs of secondary infection, including the following were present: Fever after the first 48 hours, increasing infiltrate in chest radiograph and leukocytosis. Patients with CNS depression and impaired ventilation were indicated for endotracheal intubation, mechanical ventilation and chest physiotherapy.[16-17]

Patients' initial grading was correlated with patients' outcome. The outcome parameters included: need for ICU admission, mechanical ventilation (whether invasive or non-invasive) and the length of ICU and hospital stay, as well as hospital mortality.

Statistical analysis:

The results were analyzed using SPSS ver. 15. ANOVA test was used to find the significance between the different grades of severity for the different outcomes.

3. Results

The age of the included patients ranged from 1.5 to 24 years with a mean of 6.02±5.00. 58 patients (58%) were males and 42 patients (42%) were females.

Table (1) demonstrates the baseline characteristics of the enrolled patients.

Chest X-ray of patients on admission: On admission 95% of the patients had negative findings and 5% of the patients had positive findings. ECG findings of patients on admission: On admission 100% of the patients had negative findings.

After 24 hours:
Vital signs:

MAP, HR, Temperature and RR were significantly changed after 24 hrs.

ABG:

Significant changes were noticed in pH, $PaCO_2$, PaO_2 and O_2 saturation. There was no significant change in HCO_3.

Laboratory investigations:

CBC showed significant change only in white blood cell (WBC) count. Electrolytes had changed significantly in both Na^+ and K^+. Regarding renal and liver functions, there were no significant changes.

Chest x-ray:

Positive changes were seen in 31% of patients compared to 5% on admission.

ECG:

No significant changes were observed.
Grading of the patients on admission according to PSS:
On admission, 32% of all patients (n=32) were graded as None (0), 50% (n=50) were graded as Minor (1), 14% (n=14) were graded as Moderate (2) and 4% (n=4) were graded as Severe (3).

Length of hospital and ICU stay:

Length of hospital stay for all patients ranged from 1 to 9 days with a mean of 1.65±1.28. For ICU admitted patients, the hospital stay ranged from 2 to 9 days with a mean of 3.89±1.57. Their ICU stay ranged from 2 to 8 days with a mean of 3.06±1.63.

4. Discussion:

Accidental hydrocarbon and particularly kerosene ingestion remains a serious contributor to childhood poisoning in the low socioeconomic groups, with a high incidence of morbidity and occasional mortality.[18-19] In our toxicology department, kerosene poisoning is ranked as the 3rd most common cause of admission, after "unidentified" substances and organ phosphorus compounds poisoning. In the year 2007 the number of patients admitted with hydrocarbons poisoning was 272.

The main causes of mortality in our study group were multiple organ failure (acute respiratory distress syndrome, arrhythmias, renal failure, consumptive coagulopathy and coma). This was secondary to respiratory failure and not to direct toxic insult. This was in agreement with what Nogue et al and Yu et al reported in their studies.[20-21]

Table (1): Baseline characteristics of the study population.

	Minimum	Maximum	Mean	SD
Vital signs				
Mean Arterial Pressure (mmHg)	68.00	96.00	78.27	6.59
Heart rate (Beats/minute)	75.00	130.00	106.55	9.54
Temperature (Degrees)	36.50	37.40	36.93	0.22
Respiratory rate (Breath/minute)	15.00	44.00	27.27	± 5.83
Arterial Blood Gases				
pH	7.32	7.52	7.41	0.04
Carbon Dioxide Tension (mmHg)	28.00	61.50	38.78	4.43
Oxygen Tension (mmHg)	53.00	98.00	90.48	9.62
Bicarbonate (mmol/L)	21.00	30.20	24.20	1.26
O_2 Saturation (%)	85.00	99.00	96.19	2.77
Laboratory Investigations				
Complete Blood Picture				
Hemoglobin (g/dL)	10.30	13.50	11.65	0.75
Leucocytes (k/µL)	4200.00	9300.00	6398.00	1204.03
Platelets ((k/µL)	160000	275000	210410.00	25809.75
Electrolytes				
Sodium (meq/L)	136.00	148.00	140.00	2.61
Potassium (meq/L)	3.60	4.4	3.99	0.19
Renal functions				
Blood urea Nitrogen (mg/dL)	8.00	16.70	16.70	8.00
Serum Creatinine (mg/dL)	0.60	1.20	0.88	0.16
Liver functions				
AST* (IU/L)	16.20	27.00	20.19	2.66
ALT (IU/L)**	16.50	25.60	20.34	2.29
Chest X-ray	**Negative cases**	95 (95.0%)	**Positive cases**	5 (5.0%)

*AST= Aspartate Amino Transferase, **ALT= Alanine AminoTransferase

Table (2): Relation between hospital and ICU stay and PSS grading:

	Grade				χ^2 (p)
	None	Minor	Moderate (n = 14)	Severe (n = 4)	
Hospital stay Mean ± SD	1.00 ± -	1.26 ± 0.44	3.50 ± 0.65	5.25 ± 2.99	68.529 (<0.001*)
ICU stay Mean ± SD	-	-	2.50 ± 0.65	5.00 ± 2.58	4.042 (0.044*)

***p<0.05 = significant**

Table (3) Distribution of the studied cases according to outcome.

Outcome	No.	%
Complete recovery	97	97
Need for MV		
Invasive MV	13	13.0
Non invasive MV	0	0
Need for ICU	18	18
Hospital mortality	3	3

Table (4) Relation between chest X-ray on admissionand outcome parameters:

	Admission Chest x-ray				FEp
	Negative		Positive		
	No.	%`	No.	%	
Complete recovery Yes	93	97.9	4	80.0	0.144
ICU admission Yes	13	13.7	5	100.0	<0.001*
MV Yes	10	10.5	3	60.0	0.015*
Hospital mortality Yes	2	2.1	1	20.0	0.144

Table (5): Correlation between PSS grading of patients on admission and outcome.

Outcome	Grade								MCp
	None		Minor		Moderate		Severe		
	No.	%	No.	%	No.	%	No.	%	
Complete recovery									
No	0	0.0	0	0.0	0	0.0	3	3.0	<0.001*
Yes	32	32.0	50	50.0	14	14.0	1	1.0	
FEp1			-		-		0.001*		
FEp2					-		<0.001*		
FEp3							0.005		
ICU admission									
No	32	32.0	50	50.0	0	0.0	0	0.0	<0.001*
Yes	0	0.0	0	0.0	14	14.0	4	4.0	
FEp1			-		<0.001*		<0.001*		
FEp2					<0.001*		<0.001*		
FEp3							-		
Need for MV									
No	32	32.0	50	50.0	5	5.0	0	0.0	<0.001*
Invasive	0	0.0	0	0.0	9	9.0	4	4.0	
Non Invasive	0	0.0	0	0.0	0	0	0	0.0	
MCp1			-		<0.001*		<0.001*		
MCp2					<0.001*		<0.001*		
MCp3							0.278		
Mortality									
No	32	32.0	50	50.0	14	14.0	1	1.0	<0.001*
Yes	0	0.0	0	0.0	0	0.0	3	3.0	
FEp1			-		-		0.001*		
FEp2					-		<0.001*		
FEp3							0.005*		

MCP: p for Monte Carlo test, FEp_1: p for Fisher Exact test between None and other grades, FEp_2: p for Fisher Exact test between Minor and other grades, FEp_3: p for Fisher Exact test between moderate and severe, *: Statistically significant at $p \leq 0.05$

Several studies related hydrocarbons toxic potentials and their toxicity clinical course to different factors, such as Physical characteristics e.g. (volatility is directly related to the incidence of aspiration while viscosity and surface tension are inversely related to it), and chemical characteristics e.g. (aromatic, aliphatic or halogenated hydrocarbons). Cobaugh et al reported in his study that hydrocarbons that are absorbed systemically and those with low viscosities are associated with higher hazard factors.[22-23] We could not count on these factors to triage our patients or to predict their outcomes because all of the patients included in our study were exposed to kerosene, gasoline and paint thinner which are aliphatic, highly volatile, with low surface tension and low viscosity hydrocarbons meaning that they all share the same physical and chemical characteristics. Unfortunately in our department we hardly get any case intoxicated by hydrocarbons of high systemic absorption such as aromatic and halogenated hydrocarbons.

Chest X-ray was previously known to be the most important investigation requested for patients with hydrocarbons ingestion for its diagnostic and prognostic value. Yet recent studies such as in Seymour et al and David et al proved that its correlation with physical examination may be poor as initial radiograph in symptomatic patients maybe deceptively clear and mild radiographic changes do not guarantee mild symptoms. Also admission chest X-rays contributed little to the management and the course of the illness.[23-24] In our study, chest X-ray on admission showed significant correlation with admission to the ICU and need for MV, while correlation was insignificant to complete recovery and hospital mortality. On the contrary, Anas et al. reported that abnormal initial radiographs in asymptomatic patients were not necessarily associated with a complicated course, still he agreed with the present study that radiographs were inferior to clinical signs for triage of patients with acute hydrocarbons toxicity.[25]

At Ain Shams University, Gamaluddin et al[26] conducted a study which appeared to have a principle close to ours. His goal was to derive a practical triage decision rule for use at primary health care facilities for early clinical identification of hydrocarbon ingestion/aspiration cases that will require the treatment and support services available at facilities offering higher levels of care (Ain Shams University Poison Control Centre). He depended on Integrated Management of Childhood Illness (IMCI) clinical algorithm to categorize his patients (according to their outcome) into 2 groups, resource requiring group and non-resource requiring group. Their study suggested a triage decision rule based on the presence of wheezing, altered consciousness or a rapid respiratory rate within 2 hours of exposure.

In our study, we used PSS System to categorize our patients into 4 groups (none, minor, moderate and severe) according to their clinical symptoms and their initial chest x-ray findings. We applied PSS on patients who ingested kerosene admitted to our poison centre in order to define those patients who were in need for ICU admission or expected to have a complicated course. Our goal was to correlate between their grades and their outcomes in order to apply PSS in the future for triage decision making concerning patients admitted with hydrocarbons poisoning.

Gupta et al [27]used a weighted scoring system based on clinical features and severity of illness to predict the outcome of children with kerosene poisoning. The scoring system depended on the presence or absence of: (1) Fever, (2) Severe malnutrition (3) Respiratory distress (with or without cyanosis) and (4) Neurological symptoms (with or without convulsions). The total score of each patient ranged from 0 to 10. He concluded that a score of 4 or more was found to be associated with prolonged hospital stay and complications and that the risk of dying increased if the score was equal to or more than 8.

We chose to use PSS on our patients to be more comprehensive. Though the main system targeted in hydrocarbons poisoning is usually the respiratory system still there are other systems that could be affected and deteriorate the patients' condition accordingly, e.g. syncope or arrhythmia which are the results of cardiac sensitization to catecholamines. Also the PSS system appears to represent each system involved in a sequential progression, e.g. in the respiratory system, it starts with no symptoms progressing to airway irritation followed by dyspnea and hypoxemia ending with the most severe form of cyanosis and respiratory depression. When we applied this scoring system, we concluded that patients admitted with grades ≥ 2 were more liable to develop complications and thus prolonged hospital stay was predicted. This is why we recommended immediate ICU admission for those cases.

The PSS has been elaborated, tested, and gradually revised during a project running 1991-1994. The concordance in grading the severity increased during the study period, and in the last phase there was an acceptable concordance among fourteen poisons centers in 80% or more of the cases. It is intended to be an overall evaluation of the case, taking into account the most severe clinical features.[13-14]

Pach et al assessed the concordance in severity grading when using the PSS versus specific grading scales. Severity grading was performed in all cases using both the PSS and special grading scales developed by the poison center in Krakow. An acceptable concordance between the PSS and these locally developed grading scales was found in the majority of cases but for specific poisons, like carbon monoxide, some modifications and additional criteria may be justified. The authors concluded that further studies to test the reliability of the PSS are encouraged.[28]

Davies et al [29] study showed that Glasgow Coma Score (GCS) and the PSS were similarly effective at predicting outcome of acute Organophosphorus poisoning and to assess whether patients at high risk of death could be identified accurately using clinical parameters soon after hospital admission. He concluded that patients presenting with a GCS $\leq$13 or PSS $\geq$2 need intensive monitoring and treatment. Although dealing with different toxins, we agreed with Davies studies in the part of his conclusion concerned with the PSS, as patients presented with grade $\geq$2 in our study needed immediate ICU admission for better treatment resources and mechanical ventilation. We did not use the GCS because this would have definitely resulted in underestimation of the patients' actual situation as hydrocarbons toxicity mainly affects respiratory system and GCS is a neurological scale. In addition, hydrocarbon CNS toxicity is usually affected secondary to respiratory failure. Thus it would take a relatively long time for the GCS to deteriorate in a patient presented with the life threatening grade of PSS.

Sam et al [30]evaluated the effectiveness of various severity and prognostic scales including the Acute Physiology and Chronic Health Evaluation II (APACHEII), GCS and PSS in evaluating acute Organophosphate poisoned patients at the time of admission. The mean hospitalization period and outcome of poisoning were significantly influenced by the PSS scores but not by the APACHEII or GCS scores. There was also a significant correlation found between the PSS and mortality, between the PSS grades and the need for ventilation and between PSS and incidence of intermediate syndrome (complications). Likewise, our results showed significant relation between PSS and hospital mortality, admission to the ICU, mechanical ventilation and mean hospital and ICU stay.

Pach J et al had also reported that the PSS is useful in assessing severity on the basis of observed clinical signs and symptoms (at their maximum), but does not take into account potential risks or plasma/serum concentrations.[28]

CEVIK et al [31] had a study to evaluate the relationship between the Poisoning Severity Score (PSS) and carboxyhaemoglobin (COHb) levels in patients with carbon monoxide poisoning (COP) using outcome as the measure. He found that COHb levels according to outcome were not different between PSS grades. He concluded that PSS is a reliable severity score for COP cases. However, he also recommended modifying the current PSS and for its future application to predict severity, management and outcome.

Ciszowski et al[32] used PSS to determine relations between the clinical state and the severity of liver damage comparing to the amount of ingested paracetamol, time since ingestion and serum concentration of paracetamol with patients after acute intoxication with this drug. The general clinical state was determined using the Poisoning Severity Score (PSS). Statistically significant positive correlation was found between the ingested dose of paracetamol comparing to the severity of poisoning, the severity of liver damage, levels of aminotransferases and bilirubin. A positive correlation between time since ingestion of paracetamol to hospitalization and the gravity of poisoning according to PSS scale was also statistically significant. A paracetamol concentration measured during admission to the hospital had no influence on either the clinical state of patient or the severity of liver damage.

In order to discuss different scores used to predict toxic related mortality in acute poisoning, Hantson et al[33] conducted a study which included poisoning severity scores presented by the PSS, general scores such as APACHE II, SOFA (The Sequential Organ Failure Assessment score) and SAPS (Simplified Acute Physiology II scores), neurological scales such as GCS and AVPU (Alert Verbal Pain Unconscious). They concluded that general scores lack treatment measures considerations, GCS and AVPU would be misinterpreted for fluctuating conscious level with some toxins and sedations and finally, though PSS is an outcome score yet it cannot be used to predict mortality in the ICU admitted patients, and is probably helpful to grade retrospectively the severity of poisoning. In our study we used PSS for initial grading of all patients on admission not retrospectively and the results showed the ability of the score to predict outcome including hospital mortality but not mortality in ICU admitted patients.

5. Conclusion:

According to this study, the PSS could be a useful tool to predict outcome in patients admitted with hydrocarbon toxicity as the different grades of the PSS system had significant correlation with patients' outcome. Patients presenting with hydrocarbons with a PSS of ≥ 2 could be directly admitted to the ICU for possible need of MV because of associated unfavorable outcome.

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