PATTERN AND OUTCOME OF ACUTE HYDROCARBON POISONING AMONG PATIENTS ADMITTED TO ALEXANDRIA POISON CENTER, EGYPT

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ABSTRACT

Background: Hydrocarbons are widespread, potentially dangerous substances present in fuels and household products. Toxic exposure to such compounds poses significant health consequences. **Aim of the work:** Studying pattern and outcome of acute hydrocarbon poisoning in patients admitted to Alexandria Poison Center (APC), Egypt. **Patients and methods:** Study included 178 acute hydrocarbon-intoxicated patients admitted to APC from first of January till end of June 2022. Patients were subjected to detailed history taking, clinical examination, and management. **Results:** Males constituted 64.6% of cases, with more than half of exposures in age group ≤ 3 years. Kerosene stood behind half of cases. Poisoning was accidental in 97.8% of patients. Ingestion occurred in all patients, combined with other routes in 7.9% of cases. 92.2% of patients were symptomatic, with 39.9% having irritant manifestations. Laboratory analysis showed leukocytosis (30%), metabolic acidosis (24.7%), and hypoxia (7.9%). Radiological abnormalities were recorded in 37.6% of patients, mainly increased broncho-vascular markings (BVM) (15.7%). Hydrocarbon-induced sequelae occurred in 33.1% where pneumonitis was the most common (29.7%). All patients received supportive treatment. 41.1% needed antipyretics. 3.4% of cases were admitted to ICU. 92.1% of the cases completely recovered, 6.8% were discharged against medical advice, and 1.1% of cases died. **Conclusion**: Hydrocarbon toxic exposure commonly occurs especially in pediatrics by accidental ingestion mainly of kerosene. Fever was frequently present, and pneumonitis was the most common hydrocarbon sequelae. Increased BVM was the most common radiological finding yet may not be associated with any sequelae. Hydrocarbon poisoning is usually associated with benign outcomes if managed adequately.

Keywords: *Hydrocarbons Poisoning; Kerosene; Chemical pneumonitis; Alexandria*

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INTRODUCTION

Household poisoning is responsible for high morbidities and mortalities worldwide. Hydrocarbons are one of the most prevalent household agents that induce acute poisoning, especially in developing nations. Hydrocarbons are a diverse group of organic compounds consisting of carbons and hydrogens. These chemicals are derived from petroleum distillates comprising kerosene, gasoline, mineral oils, and naphtha. They are frequently utilized as solvents, degreasers, fuels, and lubricants ***(Manzar et al., 2010; Riggan and Gummin, 2019; Armstrong and Pascu, 2022)***.

Hydrocarbons have a wide range of chemical structures hence a variety of toxic effects. They are categorized as aliphatic, cyclic, and halogenated hydrocarbons. The physical properties, volatility, surface tension, viscosity, and chemical activity of the side chains, are the determinants of pulmonary aspiration. Compounds with low viscosity, low surface tension, and high volatility like kerosene have a higher risk of deeper penetration into the distal airways (aspiration) which causes chemical pneumonia. ***(Lewander and Aleguas, 2007; Sen et al., 2013; Tormoehlen et al., 2014)***.

Other than pulmonary complications, hydrocarbons could induce dysrhythmias by enhancing myocardial sensitivity to catecholamine. In addition, acute toxic exposure to hydrocarbons might induce chemical hepatitis, kidney injury, hemolysis,

and neurotoxicity ***(Riggan and Gummin, 2019)***.

Early assessment of patients with acute hydrocarbon toxicity is critical for their proper management and for the prevention of complications. Successful management requires recognition of pulmonary aspiration and rapid initiation of appropriate supportive care which is given according to the patient's condition ***(Armstrong and Pascu, 2022)***.

American Association of Poison Control Centers in 2019 reported that hydrocarbons account for 1.54% of acute toxicities. It was suggested that the registered cases of hydrocarbon poisoning in the USA are the tip of the iceberg as not all exposures are reported to poison control centers ***(Gummin et al., 2020)***.

In developing countries, including Egypt, there is no official data that describes the burden of acute hydrocarbon poisoning however published literature reflected a high incidence of hydrocarbon-related morbidities and mortalities ***(Madboly and Elgendy, 2014; Tawfik and Elhelaly, 2015; Tawfik and Hafiz, 2017; Slima et al., 2021)***.

An in-depth analysis of the pattern of poisoning is the first step toward successful preventive strategies. In addition, a careful understanding of poisoning patterns and relevant outcomes greatly governs clinical toxicologists while managing these cases. It is worth mentioning that the poisoning pattern varies from one country to another and varies among different communities within the same country. It is modulated by different factors including the prevailing hydrocarbons within the community and the socioeconomic conditions of vulnerable populations.

THE AIM OF THE WORK

The current research studied the pattern and outcome of acute hydrocarbon poisoning in patients admitted to Alexandria Poison Center (APC), Egypt.

PATIENTS AND METHODS

Study design

This research was a prospective cross-sectional study.

Study setting and eligibility criteria

The study included all patients with acute hydrocarbon exposure who were admitted to APC within six months (from the first of January 2022 till the end of June 2022). APC is a tertiary governmental healthcare institute that serves Alexandria and surrounding governorates including El Beheira, Kafr El-Sheikh, and Matrouh which are inhabited by millions of population.

The diagnosis was based on the history of exposure, clinical features, and the distinctive smell of petroleum distillates in breath, vomitus, and feces. Patients with co-exposure to other drugs or chemicals were excluded. In addition, patients with no confirmed diagnosis of acute hydrocarbon poisoning were not included in the study ***(Hernandez, 2006)***.

Ethical considerations

The study protocol was approved by the Alexandria Faculty of Medicine's Research Ethics Committee at Alexandria University in **Egypt (Approval number: 0106934, IRB number: 00012098, FWA number: 00018699).** All patients or their guardians provided informed consent before participating in the study. Confidentiality of the patient's data was maintained.

Study methods

History taking and clinical assessment

Detailed history was taken from all patients; demographic data (age, sex, and residence), data related to poisoning (type of compound, circumstances of poisoning, route of exposure, and time from exposure to presentation), symptoms/complaints, and pre-hospital management. All cases were clinically assessed with special consideration to vital signs (pulse, blood pressure, respiratory rate, and temperature), level of consciousness using Glasgow Coma Score (GCS), and systemic examination including the respiratory and abdominal examination ***(Tawfik and Hafiz, 2017)***.

Investigations

Routine investigations were carried out including arterial blood gasses (ABG), oxygen saturation, complete blood count (CBC), liver function tests (alanine aminotransferase "ALT", aspartate aminotransferase "AST"), renal function tests (urea and creatinine), cardiac enzymes (total creatine kinase (CK-total), creatine kinase-muscle/brain (CK-MB), and troponin) as well as electrocardiography (ECG). Besides, all patients had plain chest X-ray (CXR) after six

hours from exposure and CT chest was performed when needed ***(Lung, 2017; Slima et al., 2021)***.

Treatment and follow-up

General supportive symptomatic measures for treatment were adopted for all patients, such as "nothing per os" for six hours. Skin decontamination, IV fluids, oxygen therapy and nebulizers, proton pump inhibitors, antiemetics, and purgative. Then other treatment modalities were tailored according to the patient's condition including antipyretics for fever, antibiotics for secondary bacterial infection, corticosteroids for respiratory distress, endotracheal intubation with mechanical ventilation if severe respiratory distress not responding to supplemental oxygen, and bronchodilators, chest tube insertion for tension pneumothorax, and beta-blockers for ventricular arrhythmias ***(Hernandez, 2006)***.

All patients were observed and followed up till discharge from the hospital, through regular check-ups of their clinical, laboratory, and radiological parameters.

STATISTICAL ANALYSIS

The data were documented in a specially designed sheet and statistically analyzed using the Statistical Package for Social Sciences (SPSS version 28 Chicago, IL, USA). Categorical data were described using frequency and percentage. Quantitative normally distributed data were described using mean and standard deviation (SD) while data that are not normally distributed were described using median and interquartile range (IQR).

Pearson Chi square ($\chi 2$) test was used to test for association between categorical variables, if more than 20% of cells had expected cell count less than 5, Monte Carlo significance test was applied. In all statistical tests, a level of significance of 0.05 was used.

RESULTS

The current study included 178 acutely hydrocarbon-intoxicated patients who represented 4.92% of all admitted cases (n=3612) during the six-month duration of the study. The age of the patients ranged from 6 months to 75 years with a median of 3 years (IQR 2 – 8.75).

Table (1) shows that the highest percentage of intoxicated cases was in the pediatric age from 1-12 years (71.3%) with the patients aged ≤ 3y being the most affected (58.4%). Nearly two-thirds (64.6%) of cases were males and 68.5% were from urban areas.

Kerosene was responsible for half of the acute hydrocarbon poisoned cases. 97.8% of poisoning was accidental whereas the rest were suicidal poisoning. Ingestion was the route of exposure in all cases that was associated with skin contamination and inhalation in 7.9% of cases.

Time passed since poisoning till admission ranged from half an hour to 72 hours, with a mean of 4.5±6.62 hours. 91.6% of acute hydrocarbon poisoning patients did not receive any pre-hospital intervention following the exposure.

Acute hydrocarbon exposure patients were presented with a wide variety of presentations, the most common was vomiting (57.9%) followed by cough (46.6%) and choking (31.5%). Only 7.8% of patients were completely asymptomatic.

Table (2) illustrates the clinical findings in acute hydrocarbon-intoxicated patients. It was found that (22.5%) of all hydrocarbon-poisoned patients had a disturbed level of consciousness on admission, either mild (GCS 13-14) or moderate (GCS 9-12).

Regarding the vital signs of the studied patients, 7.3% of cases were hypotensive, 28.6% had tachycardia and 32% had tachypnea. Fever was present in 41% of cases with 7.3% of patients having isolated fever without any other signs of pneumonitis either clinically (normal chest examination) or radiologically (free CXR).

It was noticed that 18.5% of acute hydrocarbon poisoning patients presented with attacks of respiratory distress. 39.9% of patients had irritant manifestations where pharyngeal erythema was the most common (19.6% of cases).

Other irritant manifestations include burning in the throat (sore throat), drooling of saliva, intolerance to oral intake, tongue ulceration, and first degree burn on chest due to skin contamination.

Table (1): Demographic data, exposure history, and on-admission symptoms of acute hydrocarbon-intoxicated patients admitted to Alexandria poison center from first of January till end of June 2022 (n= 178).

History	Count	%
Demographic data		
Age (years)		
Infant (< 1)	9	5.1%
Child (1-12)	127	71.3%
Adolescent (13-17)	5	2.8%
Adult (≥ 18)	35	19.7%
Elderly (≥ 65)	2	1.1%
Sex		
Males	115	64.6%
Females	63	35.6%
Residence		
Urban	122	68.5%
Rural	56	31.5%
Data related to poisoning		
Type of compound:		
Kerosene	89	50.0%
Benzene	36	19.7%
Paint thinners	27	15.2%
Others*	26	15.1%
Circumstances of poisoning		
Accidental	174	97.8%
Suicidal	4	2.2%
Route of poisoning		
Ingestion only	164	92.1%
Combined with skin contamination and inhalation	14	7.9%
Time passed since exposure (hours):		
Min. – Max.	0.5 – 72.0	
Mean ± SD	4.5±6.62	
Prehospital management		
No	163	91.6%
Yes **	15	8.4%
Symptoms (complaint on admission).		
Vomiting	103	57.90%
Cough	83	46.60%
Choking	56	31.50%
CNS depression	40	22.50%
Sore throat	35	19.60%
Abdominal pain	33	18.50%
Dyspnea	28	15.60%
Diarrhea	15	8.30%
Chest pain	7	4%
Drooling	6	3.40%
Hematemesis	5	2.80%
Hiccups	5	2.80%
Hemoptysis	3	1.70%
Melena	1	0.60%

**Other hydrocarbons: naphthalene, car oil, liquid varnish, greasing oil, rust remover, phenol, turpentine, citronella oil, Tetrachloroethylene, and propylene glycol. ** Prehospital management: Antibiotics, antiemetics, steroids, nebulizers, gastric lavage, antipyretics, intubation or performed CT chest*.

Table (2): Clinical assessment of acute hydrocarbon-intoxicated patients admitted to Alexandria poison center from first of January till end of June 2022 (n= 178).

Clinical examination of the patients	Count	%
GCS		
Normal (15)	138	77.5%
Mild (13-14)	30	16.9%
Moderate (9-12)	10	5.6%
Systolic Blood pressure		
Normal	153	85.95%
Hypotension	13	7.30%
Shocked	1	0.6%
Hypertension	12	6.7%
Heart Rate		
Normal	126	70.78%
Tachycardia	51	28.6%
Bradycardia	1	0.6%
Respiratory Rate		
Normal	121	68.0%
Tachypnea	57	32.0%
Temperature		
Fever	73	41%
Normal	105	59%
Chest examination		
Clear	116	65.10%
Wheezy	62	34.80%
Attacks of respiratory distress	34	19.10%
Irritant manifestations		
Present	71	39.9%
Absent	107	60.1%
Abdominal examination		
Epigastric tenderness	1	0.6%
Abdominal distension	5	2.8%
Free	172	96.6%

*-**GCS:** Glasgow Coma Score*
-Vital signs were judged according to normal reference range of each age group

Table (3) reveals that 24.7% of patients had metabolic acidosis, 7.9% had decreased oxygen saturation, and 30% had reactive leukocytosis. The mean neutrophil lymphocyte ratio (NLR) was 3.61±3.09. Most of the studied cases had normal levels of ALT and AST (96.6%) as well as normal levels of urea and creatinine (99.4%).

Cardiac enzymes are illustrated in **table (4)**. CK-total, CK-MB, and troponin were elevated in 7.9%, 5%, and 1.1% of acute hydrocarbon poisoning patients, respectively.

Radiological abnormalities were recorded in 37.6% of the studied patients. Increased BVM was the most common finding (15.7%). **Figure (1)** illustrates the initial CXR that revealed bilateral increased BVM in a patient following hydrocarbon ingestion. Other radiological abnormalities were bilateral fluffy infiltrations and right-side consolidation (9% each), Perihilar opacity (5.1%), pulmonary edema (1.7%), left lower lobe consolidation, and right transverse fissure effusion (0.6% each).

Figure (2) demonstrates examples of radiological abnormalities that appeared in the initial CXR of hydrocarbon-intoxicated patients, including bilateral fluffy infiltrations **(Figure 2A)** and perihilar opacity **(Figure 2B)**.

On radiological follow-up, progression of patches appeared in four cases (2.2%). In addition, bilateral tension pneumothorax appeared in one case (0.6%). Pneumomediastinum occurred in one case (0.6%) that was illustrated in **Figure (3)**. Whereas necrotizing pneumonia that is characterized by bilateral cavitations was found in follow-up CXR in another case (0.6%) (**Figure 4)**.

Table (3): Laboratory investigations of acute hydrocarbon-intoxicated patients admitted to Alexandria poison center from first of January till end of June 2022 (n= 178).

Investigation	Count		%
Blood gases			
ABG			
Metabolic acidosis	44		24.7%
Respiratory alkalosis	4		2.2%
mixed respiratory and metabolic acidosis	1		0.6%
Normal	129		72.5%
Oxygen saturation			
Normal	164		92.10%
Decreased <95%	14		7.90%
Min. – Max.		60 – 100	
Mean ± SD		97.5 ± 3.9	
CBC			
Hemoglobin			
Normal	87		48.80%
Increased	3		1.60%
Decreased	88.8		49.40%
Min. – Max.		7.9 – 16.7	
Mean ± SD		11.7 ± 1.6	
WBCs			
Normal	95		53.30%
Increased	53		30 %
Decreased	5		2.80%
Min. – Max.		2.9 – 33.4	
Mean ± SD		11.57 ± 4.8	
Neutrophil Lymphocyte Ratio (NLR)			
Min. – Max.		0.24 to 20.00	
Mean ± SD		3.61±3.09	
Platelets			
Normal	138		77.50%
Increased	38		21.30%
Decreased	2		1.10%
Min. – Max.		15 – 657	
Mean ± SD		335.7 ± 106.6	
Liver function tests			
AST			
Normal (15-37 U/L)	172		96.60%
Raised	6		3.4%
Min. – Max.		15 – 955	
Mean ± SD		198.8 ± 370.5	
ALT			
Normal (16-63 U/L)	171		96.60%
Raised	6		3.4%
Min. – Max.		16 – 540	
Mean ± SD		165.2 ± 186.8	
Renal functions tests			
Urea			
Normal (15-45 mg/dl)	177		99.40%
Raised	1		0.60%
Min. – Max.		6 – 77	
Mean ± SD		22.5 ± 11.9	
Creatinine			
Normal (0.7-1.3 mg/dl)	177		99.40%
Raised	1		0.60%
Min. – Max.		0.2 – 1.4	
Mean ± SD		0.5 ± 0.2	

Table (4): Cardiac enzymes and ECG of acute hydrocarbon-intoxicated patients admitted to Alexandria poison center from first of January till end of June 2022 (n= 178).

Investigation	Count	%
Cardiac enzymes		
CK-total		
Normal (up to 195 U/L)	164	92.10%
Raised	14	7.90%
Min. – Max.	25 – 965	
Mean ± SD	174 ± 137.6	
CK-MB		
Normal (up to 5 ng/ml)	169	94.90%
Raised	9	5%
Min. – Max.	0.1 – 22.5	
Mean ± SD	2.6 ± 2.9	
Troponin		
Normal (up to 0.01 ng/ml)	176	98.80%
Raised	2	1.10%
Min. – Max.	0.001 – 0.8	
Mean ± SD	0.007 ± 0.07	
ECG changes		
Normal heart rate	127	71.3%
Sinus tachycardia	51	28.6%
LBBB	1	0.6%
ST-segment elevation	1	0.6%
Multiple PVCs	1	0.6%

LBBB: left bundle branch block
PVC: premature ventricular contractions .

Figure (1): Increased BVM: Initial CXR, posteroanterior view reveals increased BVM in a young child following acute hydrocarbon poisoning.

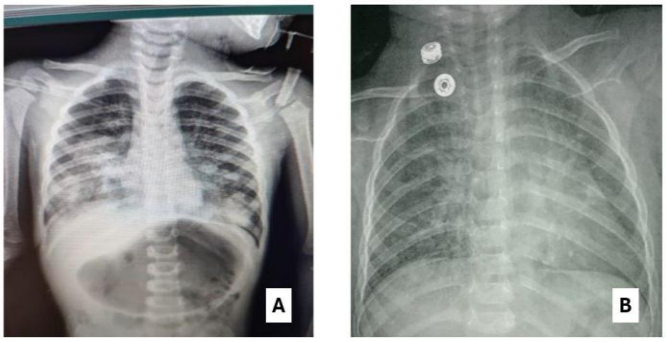

Figure (2): Pulmonary sequelae following acute hydrocarbon poisoning; (Fig. A) Bilateral fluffy infiltrations in initial CXR of a Hydrocarbon-intoxicated child (Fig. B) Perihilar opacities in initial CXR of a hydrocarbon-intoxicated child.

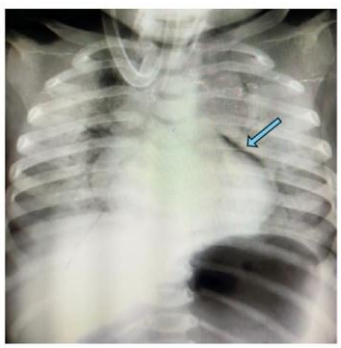

Figure (3): Pneumomediastinum: Follow-up CXR posteroanterior view reveals pneumomediastinum (blue arrow) along with pulmonary edema in an infant following acute ingestion and inhalation of kerosene.

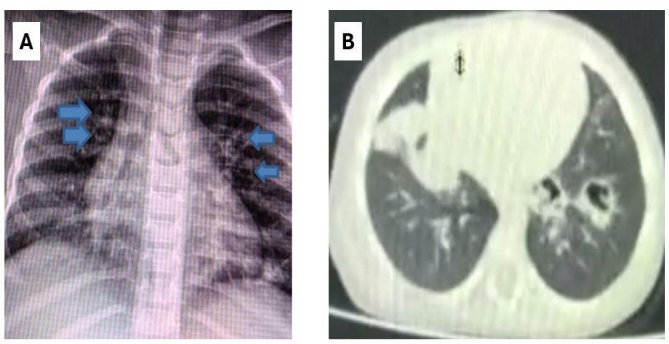

Figure (4): Delayed necrotizing pneumonia in a child following acute kerosene poisoning: (Fig. A) Follow-up CXR, posteroanterior view showing bilateral pulmonary cavitary lesion. (Fig. B) CT chest, axial view confirming presence of cavitary lesions of necrotizing pneumonia.

Table (5) shows that all studied patients received standard supportive measures then other treatment modalities were tailored according to the patient's condition. 41.1% of patients were given antipyretics and 19% received antibiotics. 12.4% required steroids for respiratory affection and 3.4% were given liver support (N-acetylcysteine and silymarin) for hepatic insult. One shocked patient needed vasopressors and sodium bicarbonate. In addition, chest tube insertion was done for one case of tension pneumothorax.

Table (6) illustrates that hydrocarbon exposure sequelae were developed in 33.1% of the studied patients. The most common sequelae were chemical pneumonitis (14%) and pneumonitis with superadded infection (15.7%).

Moreover, seven patients (4%) suffered from clinical and laboratory evidence of chemical pneumonitis (fever, tachypnea, wheezes, and leukocytosis) despite free initial and follow-up CXR. On the other hand, increased BVM in 13 cases (7.3%) was not associated with the development of any clinical manifestations or sequelae. In addition, patients who were asymptomatic on admission with free initial CXR (14 patients "7.9%") remained completely free till discharge after 24 hours.

Table (7) illustrates relations between the demographic data and the development of hydrocarbon-induced sequalae among the studied patients. There was a statistically significant difference between development of sequalae and age of the patients (p= 0.029). It was observed that percentages of patients who developed sequelae were significantly higher among younger age categories. Regarding residence, 44.6% of patients from rural areas developed sequelae which is significantly higher than those who developed sequelae from urban areas (27.9%) (*p*= 0.027). On the other hand, there was no relation between development of sequelae from hydrocarbons exposure and sex (*p*=0.088).

Moreover, there was a highly significant statistical relation between the development of hydrocarbon-induced sequelae and the following clinical parameters: choking, vomiting, severity of CNS depression, cough, fever, and respiratory distress (*p* values<0.001) **(Table 8)**.

Regarding ICU admission, six patients (3.4%) needed admission to ICU, while 172 patients (96.6%) were treated in the ward. The hospital stays of patients ranged from one hour to 672 hours (28 days) with a median of 24 hours (IQR 12 – 37.5). Considering the outcome, 92.1% of the cases completely recovered both clinically and radiologically, 6.8% were discharged against medical advice, and two patients (1.1%) died.

Table (5): Treatment modalities of acute hydrocarbon-intoxicated patients admitted to Alexandria poison center from first of January till end of June 2022 (n= 178).

Treatment received	Count	%
Supportive	178	100%
Antipyretics	73	41.1%
Antibiotics	34	19.0%
Steroids	22	12.4%
N-acetylcysteine and silymarin	6	3.4%
ETI with MV*	2	1.1%
vasopressor	1	0.6%
Sodium bicarbonate	1	0.6%
Chest tube insertion	1	0.6%
Antifungal	1	0.6%
Peptic ulcer regimen	1	0.6%

ETI with MV: Endotracheal intubation with mechanical ventilation.

Table (6):Sequelae among acute hydrocarbon-intoxicated patients admitted to Alexandria poison center from first of January till end of June 2022 (n= 178).

Patients	Count	%
No sequelae	119	66.8%
Hydrocarbon-induced sequelae	59	33.1%
Chemical pneumonitis	25	14%
Pneumonitis with superadded infection	28	15.7%
ARDS	3	1.7%
Acute coronary syndrome	2	1.1%
Hemorrhagic pulmonary edema	2	1.1%
Necrotizing pneumonia	1	0.6%
Tension pneumothorax	1	0.6%
Bleeding gastric ulcer	1	0.6%
MOD	2	1.1%

ARDS: acute respiratory distress syndrome ; MOD: multiorgan dysfunction.

Table (7): Relation between demographic data (age, sex, and residence) and development of sequalae among acute hydrocarbon-intoxicated patients admitted to Alexandria poison center from first of January till end of June 2022 (n= 178).

Demographic data	Sequalae		Statistical test (p-value)
	No (n=119)	**Yes (n=59)**	
Age group	**Count (%within each category)**	**Count (% within each category)**	MCp
Infant (<1) (n=9)	4 (44.4%)	5 (55.6%)	(0.029*)
Child (1-12) (n=127)	79 (62.2%)	48 (37.8%)	
Adolescent (13-17) (n=5)	4 (80%)	1 (20%)	
Adult (≥ 18) (n=35)	30 (85.7%)	5 (14.3%)	
Elderly (≥ 65) (n=2)	2 (100%)	0 (0%)	
Sex			
Males (n=115)	82 (71.3%)	33 (28.7%)	$\chi 2$
Females (n=63)	37(58.7%)	26 (41.3%)	(0.088)
Residence			
Rural (n=56)	31 (55.4%)	25 (44.6%)	$\chi 2$
Urban (n=122)	88 (72.1%)	34 (27.9%)	(0.027*)

*MCP: Monte Carlo significance ; $\chi 2$: Pearson Chi square test ; *Statistically significant at $p \leq 0.05$.*

Table (8): Relation between the clinical parameters and development of sequalae among acute hydrocarbon-intoxicated patients admitted to Alexandria poison center from first of January till end of June 2022 (n= 178).

Clinical parameters	Sequalae		p value
	No (count=119)	**Yes (count=59)**	
Choking	**Count (%within each category)**	**Count (%within each category)**	
No (n=122)	100 (82%)	22 (18%)	
Yes (n=56)	19 (33.9%)	37 (66.1%)	<0.001*
Vomiting			
No (n=75)	67 (89.3%)	8 (10.7%)	
Yes (n=103)	52 (50.5%)	51 (49.5%)	<0.001*
CNS depression			
No (n=138)	105 (76.1%)	33 (23.9%)	
Mild (n=30)	12 (40%)	18 (60%)	
Moderate (n=10)	2 (20%)	8 (80%)	<0.001*
Cough			
No (n=95)	77 (83.7%)	15 (16.3%)	
Yes (n=83)	42 (50.6%)	41 (49.4%)	<0.001*
Fever			
No (n=105)	94 (89.5%)	11 (10.5%)	
Yes (n=73)	25 (34.2%)	48 (65.8%)	<0.001*
Respiratory distress			
No (n=144)	117 (81.2%)	27 (18.8%)	
Yes (n=34)	2 (5.9%)	32 (94.1%)	<0.001*

**Statistically significant at $p \leq 0.05$ by Pearson Chi square test.*

DISCUSSION

Hydrocarbons are common and widely spread compounds that are found in numerous household products. Toxicity from such compounds results in significant health consequences ***(Riggan and Gummin, 2019)***.

During six months, 178 patients with acute hydrocarbon poisoning were admitted to the APC, representing 4.92% of all admitted cases during this period. This rate was near to the ***Madboly and Elgendy, (2014)*** study of acute hydrocarbon exposures at the Benha Poisoning Control Unit, representing 6.4% of the total intoxicated patients. However, ***Tawfik and Hafiz, (2017)*** study at Ain Shams Poison Center showed lower rates representing 1.5% of the total intoxicated patients.

In the current study, the highest number of intoxicated cases was in pediatrics particularly those aged 3 years or less with male predominance. The vulnerability of the pediatric age group especially males to hydrocarbon poisoning was previously reported in Egyptian studies conducted in Ain Shams ***(Tawfik and Hafiz, 2017)*** and Menoufia ***(Slima et al., 2021)*** and also in ***(Sunilkumar and Parvathy, 2016; Hatti et al., 2018; Kulkarni et al., 2019; Karthika et al., 2021)*** studies in India, ***(Anwar et al., 2014)*** study in Bangladesh, and ***(Palmer et al., 2023)*** study in the USA. This could be attributed to easy accessibility, availability of hydrocarbon-containing products with unsafe storage practices, absence of supervision, and more hyperactivity and exploratory behavior among male children.

The present research demonstrated that cases from urban areas (68.5%) outnumbered those from rural areas (31.5%). This was in contrast with other studies in Benha ***(Madboly and Elgendy, 2014)*** and Menoufia ***(Slima et al., 2021)***, where cases from rural areas were higher. Such variation could be attributed to the geographical location of APC.

Kerosene stood behind half of the hydrocarbon poisoning cases enrolled in the present study agreeing with ***Madboly and Elgendy, (2014)***, and ***Tawfik and Hafiz, (2017)*** studies on Egyptians where kerosene constituted (66.7%) and (83.5%) of poisoned cases respectively. Also, ***Hatti et al., (2018)*** and ***Karthika et al., (2021)*** studies on Indians mentioned kerosene as the most commonly involved agent representing 71.1% and 71.4% of hydrocarbon-intoxicated patients respectively. This denotes the wide availability of kerosene in developing countries. On the other hand, gasoline was the most ingested hydrocarbon in the USA ***(Gummin et al., 2020; Palmer et al., 2023)***.

In the current study, 97.8% of the studied patients ingested hydrocarbons accidentally. Similarly, ***Anwar et al., (2014)*** from Bangladesh, ***Tawfik and Hafiz, (2017)*** from Egypt, ***Karthika et al., (2021)*** from India, and ***Eizadi-Mood et al., (2022)*** from Iran reported that most of the toxic exposure to hydrocarbons was accidental.

In the present work, 92.2% of hydrocarbon-intoxicated patients were presented with a wide range of symptoms where the most common were vomiting (57.9%) and cough (46.6%). This was consistent with a study conducted by ***Hatti et al., (2018)*** who reported that 77% of the studied patients were symptomatic with vomiting being the most common (67.3%) also followed by cough (46%).

Likewise, ***Karthika et al., (2021)*** mentioned that 95.3% of hydrocarbon-poisoned patients were symptomatic where vomiting was the most observed symptom (57%).

Fever was evident in 41% of enrolled cases in the current work. Similarly, it was present in 28.8% of cases in the study conducted by ***Hatti et al., (2018)*** which could be explained by the resultant pneumonitis with or without superadded infection. It is worth mentioning that isolated fever occurred in 7.3% of the patients in the current study in the absence of clinical or radiological evidence of chemical pneumonitis. Therefore, It was postulated that fever occurred as a part of the systemic inflammatory response induced by toxic hydrocarbon exposure ***(Chakraborty and Burns, 2023)***.

In the present study, 32% of cases had tachypnea. Tachypnea could be explained by aspiration as the majority of tachypneic patients developed chemical pneumonitis, also it could be a compensatory mechanism to the developed metabolic acidosis ***(Tormoehlen et al., 2014)***. Moreover, 18.5%

of cases in this study presented with attacks of respiratory distress. Similarly, ***Madboly and Elgendy, (2014)*** reported that 12.5% of patients developed respiratory symptoms. This hydrocarbon-induced pulmonary injury could be attributed to aspiration which most often occurs during or after ingestion ***(Lee and Bye, 2019; Naeem et al., 2024)***.

Metabolic acidosis was present in 24.7% of cases in the current study which could be due to the production of organic acids during hydrocarbon metabolism ***(Tormoehlen et al., 2014)***. In addition, 7.9% of patients had hypoxia which coincides with the results of ***Slima et al., (2014)*** study. Hypoxia could be attributed to pulmonary affection including destruction of surfactant and inflammatory response ***(Lee and Bye, 2019)***.

Leukocytosis was reported in 30% of the studied patients which was consistent with ***Kulkarni et al., (2019)*** *and* ***Karthika et al., (2021)*** studies in which leukocytosis was found in 48.6% and 62% of cases, respectively. Increased leucocytic count could denote the development of hydrocarbon-related chemical pneumonitis ***(Hatti et al., 2018; Karakasi et al., 2020)***.

In the current study, 3.4% of patients had elevated ALT and AST levels; Liver injury related to hydrocarbon exposure was also reported by ***Teschke, (2018)*** and ***Agrawal et al., (2020)*** who attributed hepatic insult to the toxic metabolites of hydrocarbons that are generated in the liver with subsequent hepatotoxicity. In the present research CK-total, CK-MB, and troponin were elevated in 7.9%, 5%, and 1.1% of the studied patients, respectively. This could be explained by hydrocarbon-induced myocardial injury ***(Jolly et al., 2021)***.

Regarding the radiological findings, 37.6% of patients in the current study had abnormal findings in CXR mainly in the form of increased BVM (15.7%) followed by bilateral fluffy infiltrations and right-side consolidation (9% each). Similarly, ***Madboly and Elgendy, (2014)*** reported increased BVM in (51.2%) of their cases. Whereas, ***Sunilkumar and Parvathy, (2016)*** found that 82% of acute kerosene-poisoned patients showed different degrees of infiltrations in the lung where 56% were right-sided.

Considering the progression of the chest radiological abnormalities in the present study; bilateral tension pneumothorax, pneumomediastinum, necrotizing pneumonia, and progression of patches appeared in some patients. Similar studies reported that perihilar infiltrates that appeared in the initial radiographs may coalesce to form patches of consolidation or remain non-confluent ***(Jayashree et al., 2006; Marchiori et al., 2010)***.

Various hydrocarbon exposure sequelae were evident in 33.1% of the patients in the current study. The sequelae included chemical pneumonitis with or without superadded infection, necrotizing pneumonia, tension pneumothorax, and pneumomediastinum. Similar respiratory complications were reported in other studies ***(Choudhuri et al., 2014; Bajpai et al., 2019; Rajpoot et al., 2022; Subhani et al., 2023; Barzallo et al., 2023)***

It is worth mentioning that 7.3% of patients in the current work had increased BVM, yet they did not develop any sequelae. On the other hand, 4% of patients had clinical and laboratory signs of chemical pneumonitis despite completely free initial and follow-up CXR. This agreed with ***(Makrygianni et al., 2016)*** and ***(Tawfik and Hafiz, 2017)*** who stated that chest radiography was not always an indicator of clinical pneumonitis. In addition, patients in the present study who were asymptomatic on admission with free initial CXR (7.9%) remained completely free till discharge after 24 hours.

In the current research, it was found that younger age categories were significantly liable to develop hydrocarbon-related sequelae compared with older patients who agree with the results of ***Palmer et al., (2023)*** who investigated acute hydrocarbon poisoning in the USA.

Regarding residence, the current study found that a significantly higher percentage of hydrocarbon-intoxicated patients who developed sequelae were from rural areas. This could be explained by the delayed medical care seeking by patients from rural areas which are located far away from APC.

As regards the clinical parameters, the present study pointed to vomiting, choking, cough,

and CNS depression as alarming symptoms that were significantly associated with hydrocarbon-related sequelae. Generally, in intoxicated patients, vomiting, choking, coughing, and CNS depression are associated with an increased risk of aspiration and progressive lung injury ***(Eizadi-Mood et al., 2018; Košutova and Mikolka, 2021)***. Among hydrocarbon-intoxicated patients, ***Tawfik and Hafiz (2017)*** reported that respiratory distress and CNS depression were significantly related to poor outcomes which are in agreement with the current study. Also, ***Hatti et al., (2018)*** revealed a statistically significant relation between vomiting and the development of pneumonia.

In addition, the current research denoted that fever and respiratory distress were significantly associated with hydrocarbon-related sequelae. The presence of fever and respiratory distress could indicate the development of hydrocarbon-related pneumonia ***(Makrygianni et al., 2016)***.

In the current study, only 3.4% of the patients needed ICU admission which was less than the percentage of ICU-admitted patients in ***Tawfik and Hafiz, (2017)*** study which reached 6.7% and ***Karthika et al., (2021)*** study which reached 9.5%. The duration of hospital stays in the present study ranged from one hour to 672 hours (28 days) with a median (IQR) of 24 (12 – 37.5) hours. The one-hour hospital stay was in one severe case who died after one hour from arrival at the hospital. On the other hand, the 28-day-duration hospital stay was for a patient who developed acute necrotizing pneumonia and needed extended medical care. It is noteworthy that the hospital stay ranged from one to 12 days with a mean of 3.14 and from one to 10 days with a mean of 5 in studies conducted by ***Kulkarni et al., (2019)*** and ***Karthika et al., (2021)*** respectively. Variations in case severity and follow-up policies stand behind variations in the time of hospitalization.

Studying the outcome of the current studied patients revealed that 92.1% of the cases recovered completely, 6.8% were discharged against medical advice, and 1.1% died. In other Egyptian studies; ***Madboly and Elgendy, (2014)*** reported that 91.7% of patients were fully recovered, 8.3% were discharged against medical advice and no deaths were recorded, while in ***Slima et al., (2014)*** study, 76% were cured, 22.1% were discharged against medical advice and 1.9% died. Similarly, in ***Hatti et al., (2018)*** study on Indians, 92.3% completely recovered, discharge against medical advice was reported in 7.7% and there were no deaths.

The hydrocarbon-related deaths in the current study could be attributed to massive pulmonary impairment that progressed to acute respiratory failure and multiorgan dysfunction. This agreed with other studies that reported multiorgan failure after acute hydrocarbon poisoning ***(Jolly et al., 2021; Rufener et al., 2022; Hoody et al., 2023)***.

CONCLUSION

The present research investigated the pattern and outcome of acute hydrocarbon poisoning in patients admitted to APC, Alexandria, Egypt. This study pointed to accidental exposure to hydrocarbons, especially kerosene, in the pediatric age group as a common toxicological emergency. Symptomatic cases represented 92.2%, and the most common complaints were vomiting, coughing, choking, and disturbed consciousness. Hydrocarbon-related sequelae were more common among younger children and those from remote rural areas. Clinically, hydrocarbon-intoxicated patients who presented with vomiting, fever, choking, cough, CNS depression, and respiratory distress were most liable to suffer from pulmonary sequelae. The current study denoted that hydrocarbon poisoning is associated with benign outcomes if managed adequately. Pneumonitis was the commonest recorded hydrocarbon-related sequelae. Only a tiny fraction of patients developed fatal complications.

Chest radiography is frequently used to assess hydrocarbon-related pulmonary effects. Increased BVM, bilateral fluffy infiltrations, and right-side consolidations were the most common findings in the initial CXR.

Follow-up CXR revealed the development of other hydrocarbon-related sequelae, including pneumothorax and pneumomediastinum. It is worth mentioning that asymptomatic patients on admission with free initial CXR remained

completely free until discharge. Some patients had clinical and laboratory signs of pneumonitis despite completely free initial and follow-up CXR. On the other hand, other patients had increased BVM in their initial CXR and didn't have any pulmonary sequelae, including pneumonitis.

The current study could serve as a valuable reference that could encourage the implementation of preventive measures to decrease the incidence of hydrocarbon poisoning in Egyptian communities. The present results might benefit clinical toxicologists who are engaged in managing acute hydrocarbon poisoning. The present study was a descriptive study that focused on the history, clinical manifestations, and investigations of intoxicated patients.

RECOMMENDATIONS

- There is a necessity to decrease the incidence of hydrocarbon poisoning through raising public awareness of its dangerous health effects. It is advisable to avoid unnecessary availability of hydrocarbons in homes and provide specially labeled bottles for household products out of reach of children.
- Utmost care and careful follow-up are recommended for any hydrocarbon-intoxicated patients with one or more risk factors.
- Follow-up CXR is recommended if there are radiological findings in the initial assessment of hydrocarbon-intoxicated patients.
- A comprehensive evaluation of hydrocarbon-intoxicated patients using CXR along with clinical assessment and laboratory investigations is needed.
- It is recommended to conduct similar research assessing hydrocarbon-intoxicated patients using clinical scores such as SAPS II (Simplified Acute Physiology Score II), APACHE II (Acute Physiology and Chronic Health Evaluation II), REMS (Rapid Emergency Medicine Score), and MEWS (Modified Early Warning Score). Additionally, the conduction of future studies that are concerned with the adoption of models predicting the outcomes of acute hydrocarbon poisoning is recommended.

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نمط ونتائج تسمم الهيدروكربون الحاد لدى مرضى مركز السموم بالإسكندرية، مصر

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الملخص العربى

المقدمة: توجد الهيدروكربونات على نطاق واسع في الوقود والمنتجات المنزلية حيث يشكل التعرض السام لها عواقب صحية كبيرة.

هدف البحث: دراسة نمط ونتائج التسمم الهيدروكربوني الحاد لدى المرضى مركز السموم بالإسكندرية، مصر

منهجية البحث: شملت الدراسة ١٧٨ مريضًا مصابًا بتسمم الهيدروكربون الحاد الذين تم دخولهم إلى مركز السموم بالإسكندرية في الفترة من الأول من يناير وحتى نهاية يونيو ٢٠٢٢. وقد تم أخذ التاريخ المرضي لجميع الحالات كما تم فحصهم سريريا واتخاذ جميع التدابير العلاجية.

النتائج: شكل الذكور ٦٤.٦% من الحالات، وكان أكثر من نصف حالات التعرض في عمر ٣ سنوات أو أقل. كان الكيروسين مسؤولاً عن نصف عدد المرضى. كان التسمم عرضياً في ٩٧.٨٪ من الحالات كما حدث عن طريق الابتلاع لدى جميع المرضى، بالإضافة إلى طرق أخرى في ٧.٩% من الحالات. ٩٢.٢% من المرضى كان لديهم أعراض حيث عانى ٣٩.٩% من أعراض تهيج بالاغشية المخاطية. أظهرت التحاليل المختبرية زيادة عدد الكريات البيضاء (٣٠٪)، والحماض الأيضي (٢٤.٧٪)، ونقص الأكسجين (٧.٩٪). ظهرت العواقب الناجمة عن الهيدروكربون في 33.1% من الحالات حيث كان الالتهاب الرئوي هو الأكثر شيوعاً (٢٩.٧%). تم تسجيل نتائج إشعاعية لدى ٣٧.٦% من المرضى، وبشكل رئيسي زيادة العلامات القصبية الوعائية (BVM) (١٥.٧%). تلقى جميع المرضى العلاج الداعم كما احتاج ٤١.١% لخافضات الحرارة. احتاج ٣.٤% من الحالات الدخول إلى العناية المركزة. وقد تم شفاء ٩٢.١% من الحالات تماماً، وخرج ٦.٨% خلافاً للمشورة الطبية بينما توفى ١.١%.

الخلاصة: يحدث التعرض السام للهيدروكربون بشكل شائع خاصة عند الأطفال عن طريق الابتلاع العرضي للكيروسين بشكل رئيسي. وُجدت الحمى بشكل متكرر وكان الالتهاب الرئوي أكثر العواقب الهيدروكربونية شيوعًا. كانت زيادة BVM هي النتيجة الإشعاعية الأكثر انتشاراً ومع ذلك قد لا يصحبها أي عواقب. عادة ما يرتبط التسمم الهيدروكربوني بنتائج حميدة إذا تم اتخاذ التدابير العلاجية بشكل مناسب.