ORIGINAL RESEARCH

Hydrocarbon Poisoning in Children: A 5-Year Retrospective Study

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Objective.—To investigate the demographics, incidence, and symptoms and signs of hydrocarbon poisoning in admitted children from the Negev Desert area of Israel.

Methods.—The medical records of all children admitted for hydrocarbon poisoning from 1995 to 1999 were reviewed retrospectively.

Results.—Of the 274 admitted children, 61% were boys and 39% were girls, with ages ranging from 6 months to 18 years (median, 1.58 years). Ninety-four percent of the patients were Moslem Arab Bedouins, and 6% were Jews. The largest group of patients (106) was admitted during the summer months ($P < .003$). Also, more patients were admitted in spring (63) and autumn (67) than in winter (38) ($P < .013$). Thirty-two percent of the cases were seen in the Pediatrics Ambulatory Unit and then discharged, while 68% were hospitalized. The most commonly observed symptoms were tachypnea (73.7%), fever (63.5%), vomiting (51.1%), and cough (38.0%). About one third of the patients showed signs of central nervous system (CNS) impairment, including drowsiness, restlessness, stupor, and convulsions. These symptoms were significantly correlated with pneumonia, hypoxemia, and fever ($P < .001$). Of 274 patients, 43% (118 children) had pneumonia—usually interstitial pneumonitis (90%). Vomiting was significantly correlated with pneumonia ($P < .05$).

Conclusions.—1) There is a higher risk of hydrocarbon poisoning during the hot months of the year; 2) the respiratory system is the main target organ affected; 3) pneumonia is in most cases interstitial and bilateral; 4) vomiting after hydrocarbon ingestion is related to the rate of development of pneumonia; 5) symptoms of CNS impairment were correlated with hypoxemia, pneumonia, and fever; and 6) CNS toxicity may occur without hypoxemia, concurrent pulmonary pathology, or other pathology.

Key words: kerosene, hydrocarbon, children, pneumonia, vomiting, central nervous system toxicity

Introduction

Accidental hydrocarbon poisoning continues to be a major problem in children^{1,2} and is prevalent mostly in low socioeconomic groups.^{3,4} The Soroka University Medical Center, Beer-Sheva, is the only hospital that serves the Negev Desert area of Israel. It caters to a population of about 400 000 that consists of 2 distinct ethnic groups: Jews (80%) and Bedouins (20%). Bedouin families tend to be large, and most live in huts and tents, generally in overcrowded conditions. Proper parental supervision is often lacking. Kerosene is kept on hand for cooking, heating, and lighting and is usually stored in the living

area. This situation presents a serious risk factor for Bedouin children. Our previous study⁵ showed that ingestion of household materials is one of the major causes of poisoning in children. In the present study, we summarize data on hydrocarbon poisoning in our region between 1995 and 1999.

Patients and methods

All cases of children diagnosed with hydrocarbon poisoning were taken from the computerized database of the Soroka University Medical Center, Beer-Sheva, Israel, from a 5-year period (1995–99). The medical records of these children were reviewed retrospectively. One researcher recorded the data from the medical files extracted from the database for each child using a stan-

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dard form, which included an evaluation of clinical symptoms, a report of chest radiographic findings, a complete blood cell count, and a blood chemical analysis.

Statistical analysis

For ordinal data, the chi-square test was used. For the correlation evaluation of dichotomous nominal data, the chi-square test and the Yule coefficient of association (Q) were used, with a significance level of $P < .05$.

Results

Of the 274 admitted patients, 168 (61%) were boys, and 106 (39%) were girls ($P < .0002$). Ninety-six percent (263 patients) were from rural areas, and 4% (11 patients) were from urban areas. Ninety-four percent of the patients (257 children) were Moslem Arab Bedouins, and 6% were Jews. Ages ranged from 6 months to 18 years (median, 1.58 years). Ninety-two percent of the patients were 3 years and younger. Ninety-six percent of the patients (263) were poisoned by kerosene; of the remaining 4%, 8 children ingested gasoline, and 3 children were poisoned with acetone, turpentine, or thinner. Two hundred sixty-eight children (98%) suffered accidental poisoning by mistaking the toxic agent for water, while 6 adolescents (2%), aged 15 to 18 years, ingested kerosene in a suicide attempt. According to the medical records of 77 patients, the volume of hydrocarbon ingested was 1 swallow to 150 mL. However, such data are unreliable, as the amount of hydrocarbon stored is usually unknown, and under such conditions, the liquid is frequently spilled. Ninety-eight percent of the children (269 patients) ingested the toxic matter, and 2% (5 children) were poisoned by inhalation. Fifty-one percent of the patients (141 children) were admitted within 1 hour of the poisoning incident; 27% (75 children), within 1.5 to 8 hours; and 4% (12 children), within 9 to 24 hours. For 17% of the patients (46 children), no data were available regarding the time of poisoning. The number of patients admitted in winter, spring, summer, and autumn was 38, 63, 106, and 67, respectively. Statistical analysis revealed a significantly higher prevalence of kerosene poisoning in the summer than in the winter, spring, or autumn ($\chi^2 = 32.1$, $P < .0001$; $\chi^2 = 10.9$, $P < .001$; and $\chi^2 = 8.79$, $P < .003$, respectively). More cases of kerosene poisoning occurred in spring and autumn than in winter ($\chi^2 = 6.19$, $P < .013$; and $\chi^2 = 7.08$, $P < .008$, respectively).

Signs and symptoms of hydrocarbon poisoning are presented in Table 1. The most common findings were tachypnea, fever, vomiting, and cough, which occurred

Table 1. Signs and symptoms in 274 hydrocarbon-poisoned patients

<i>Signs and symptoms</i>	<i>No. patients</i>	<i>Patients (%)</i>
Fever	174	63.5
Vomiting	140	51.1
Cough	104	38.0
Tachypnea	202	73.7
Lung ronchi	94	34.3
Grunting	27	9.9
Intercostal retractions	47	17.2
Decreased breath sounds	34	12.4
Crepitations	26	9.5
Hypoxemia (hemoglobin oxygen saturation <94%)	76	27.7
Drowsiness	54	19.7
Restlessness	15	5.5
Drowsiness intermittent with restlessness	11	4.0
Stupor	4	1.5
Convulsions	2	0.7
Abdominal distention	5	1.8

in 73.7%, 63.5%, 51.1%, and 38.0% of the patients, respectively. About one third of the patients (86 of 274) had symptoms of central nervous system (CNS) agitation or depression including drowsiness, restlessness, alternating drowsiness and restlessness, stupor, and convulsions. Statistical analysis for dichotomous nominal scale data revealed a significant correlation between CNS involvement and pneumonia ($Q = .439$, $\chi^2 = 11.9$, $P = .0006$); hypoxemia ($Q = .687$, $\chi^2 = 39.6$, $P < .0001$); and fever ($Q = .490$, $\chi^2 = 12.1$, $P = .0005$). These statistics indicated that only 9.3% (8 of 86 children) of the patients with CNS symptoms did not have pneumonia, hypoxemia, or fever.

Hematologic analysis (Table 2) revealed the presence of leukocytosis in 135 children. Sixty-four of these patients showed a shift to the left on the white blood cell differential. Statistical analysis revealed that 75% of 115 patients (86 children) with pneumonitis had leukocytosis, whereas only 32% (49 children) of 153 patients without pneumonitis had leukocytosis ($\chi^2 = 18.7$, $P < .0001$). Fifty percent of 86 patients with pneumonitis and leukocytosis showed a shift to the left; in the group without pneumonitis, the white blood cell count showed a shift to the left in 43% of the 49 children with leukocytosis ($\chi^2 = 0.1$, $P = .75$). These data do not include the 6 patients suffering from acute otitis media who had leukocytosis.

In the emergency room, all children were bathed and received first aid, along with treatment, such as intra-

Table 2. Results of hematologic analysis in patients with hydrocarbon ingestion*

Patients	Patients with leucocytosis (thousands of leukocytes per mm ³ of blood)			No. patients with leukocytosis	Patients with shift to the left†
	>10–15	>15–20	>20		
With pneumonia	20	33	33	86	43
Without pneumonia	20	18	11	49	21

*These data do not include 6 patients with acute otitis media, all of whom had leukocytosis.

†Greater than or equal to 1500 stabs per cubic millimeter of blood.

venous fluid and oxygen, if necessary. Thereafter, they were transferred to the General Pediatrics Ambulatory Unit, the General Pediatrics Ward, or the Children's Intensive Care Unit for observation and treatment.

Thirty-two percent (88 children) of the 274 patients were observed in the General Pediatrics Ambulatory Unit for up to 14 hours (including the time spent in the emergency room). Twenty-two of these ambulatory patients (28%) had a fever (rectal temperature, 38°C and higher), 16 of whom were treated with acetaminophen. Only 1 child showed upper respiratory tract infection and lung infiltrate on chest radiogram. He was discharged 12 hours after admission, as his clinical state was stable.

Sixty-eight percent (186 children) were hospitalized in a pediatric ward. Duration of hospitalization ranged from 1 to 24 days (mean $\pm$ SD, 2.84 $\pm$ 2.81). Twenty percent (38 of 186 children) of the in-patients required

only observation for 1 to 2 days and were discharged in a stable state. Sixty-three percent (118 children) had pulmonary pathology on chest radiography (Table 3). There was significant statistical correlation between vomiting and pneumonia ($Q = .257$, $\chi^2 = 4.05$, $P = .044$). Forty-one percent of the children with lung disease (48 of 118 children) were treated with antibiotics (either cefuroxime, or amoxicillin plus clavulanic acid) because of suspected secondary infection. Six in-patients received antibiotics for acute otitis media. One hundred fifty-two hospitalized patients had a fever of 38.0°C to 40.8°C, 131 of which were treated with acetaminophen (suppository, syrup, or tablet form) and/or ibuprofen (syrup). Forty-eight in-patients received intravenous fluids for mild dehydration and vomiting. Sixty-one obtained oxygen therapy for respiratory distress and low oxygen saturation.

Twelve (6.5%) of the 186 hospitalized children aged 1 to 3 years (mean $\pm$ SD, 1.4 $\pm$ 0.5 years) were treated in the intensive care unit (ICU) because of severe respiratory distress and CNS toxicity (4 children had stupor, 5 children had drowsiness, 2 children had restlessness, and 1 child had intermittent drowsiness and restlessness). Ten of these children had pneumonia. The 2 remaining children showed no signs of pneumonia. All 12 children received intravenous fluids along with oxygen, and 3 required mechanical ventilation for severe respiratory failure. Six of the 12 ICU hospitalized patients were placed on antibiotics for suspected secondary bacterial infection.

Of the 6 adolescent patients hospitalized for attempting suicide, 5 were females and 1 was male. All of the females attempted suicide because of family problems. The male was a victim of drug (cannabis) and alcohol addiction. At the time of his suicide attempt, he was inebriated. One patient had a fever (38.5°C), for which he received a single dose of acetaminophen. Others manifested no symptoms of poisoning. All of these adolescents were seen by a social worker and underwent psychiatric evaluation.

Table 3. Chest radiographic findings among 118 patients with lung pathology

Diagnosis	Patients, %	
	No. patients	(of 115 cases of pneumonia)
Right lung interstitial pneumonitis	22	19.1
Left lung interstitial pneumonitis	4	3.5
Bilateral interstitial pneumonitis*	61	53.0
Interstitial pneumonitis with unknown localization	17	14.5
Right lung lobar pneumonia†	5	4.3
Left lung lower lobe pneumonia	6	5.2
Atelectasis	1	
Pneumatocele	1	
Pneumatocele pneumothorax	1	
Total	118	

*In 13 cases, the pneumonitis was located in the lower lobe of both lungs.

†Four cases of right lower lobe and 1 case of right middle lobe pneumonia.

All 274 children admitted for hydrocarbon poisoning survived and were discharged in good condition.

Discussion

Accidental kerosene ingestion remains a serious contributor to childhood poisoning in low socioeconomic groups,^{2,3} with a high incidence of morbidity and occasional mortality.^{6,7} Kerosene and other hydrocarbon toxicities affect mainly the respiratory system and the CNS. Respiratory symptoms (gasping, choking, grunting, coughing, and intercostal retractions) are the earliest signs of kerosene ingestion, and pulmonary pathology is the most serious complication. Experimental toxicologic studies have shown that aspirated, but not ingested, kerosene affects the respiratory system.⁸ Sufficient evidence has demonstrated the rapid onset of symptoms after hydrocarbon vapor inhalation or liquid aspiration.^{9,10} In vivo experiments also reveal immediate lesions in the lungs of animals after hydrocarbon exposure.¹¹ Because of their high volatility, low viscosity, and low surface tension, hydrocarbons penetrate into distal airways and spread over a large area of lung tissue.¹¹ Pulmonary lesions produced by these substances present a combination of lung irritation with loss of surfactant and features of lipoid pneumonia.^{12,13} The etiology of CNS symptoms (headache, dizziness, drowsiness, restlessness, seizures, and coma) is not clear, but hypoxia has been suggested as the main cause.¹⁴ Gastrointestinal involvement (nausea, vomiting, abdominal pain, and diarrhea) has been attributed to mucosal irritation.¹⁵

Our data show that, in our area, 94% of the hydrocarbon-poisoned patients are Arab Bedouin children. The economic level of most of these families is low, and they tend to live in rural regions of the Negev Desert in overcrowded conditions. Kerosene is a common household commodity. Parental supervision is often lacking; therefore, these children are at high risk for kerosene poisoning. Similar to a South African study,⁴ our investigation indicates that a statistically significant larger number of cases of hydrocarbon poisoning occurred in summer than in winter, spring, or autumn and a higher incidence in spring and autumn than in winter. During hot seasons, the child is likely to be thirsty and may mistake kerosene (or another hydrocarbon) for water or another cold drink. Patients were predominantly boys, and 92% were 3 years and younger. These data are similar to those found in other studies, which reported a high incidence of kerosene poisoning in boys 3 years and under.^{1-3,16} Also, similar to other investigators,^{3,9,10} we found a high prevalence of symptoms relating to the respiratory system, and about 60% of the patients had a fever (38°C or greater).^{3,17} Vomiting after ingestion oc-

curred in half of our patients and was significantly correlated with pneumonitis. This result is in agreement with experimental data showing that kerosene aspiration causes the development of pulmonary pathologies.^{8,11,12} It also agrees with the findings of another study,¹⁸ in which it was suggested that vomiting after kerosene ingestion may cause aspiration. In contrast to our findings, Dudin et al¹⁹ did not find an increased risk of respiratory complications related to vomiting after kerosene ingestion. This might be because of the relatively small number of patients in their study. Pulmonary abnormalities were manifested predominantly in interstitial pneumonitis that was mostly bilateral.

Fever, symptoms of CNS impairment, and hypoxemia were frequent findings. Hypoxemia and fever as well as pneumonia were significantly correlated with symptoms of CNS involvement ($P < .001$). It is widely accepted that hypoxia is the cause of CNS symptoms in cases of kerosene poisoning. Majeed et al²⁰ reported a close relationship between the severity of pulmonary involvement and the development of neurologic complications. It can be speculated that fever exacerbates CNS impairment. However, 9% of our patients with CNS symptoms had no hypoxemia, pneumonia, or fever. Thus, according to our results, other factors (eg, a direct CNS hydrocarbon toxic effect) may also play a role in the pathogenesis of CNS involvement.

Leukocytosis is an indication of pneumonitis, and our study showed a 2.3 times higher incidence of leukocytosis in children with radiologically documented pneumonitis than in children without.

Medical care was mainly supportive. Patients received antipyretics, intravenous fluids and electrolytes, and humidified oxygen when necessary. Antibiotics were prescribed when supportive treatment proved insufficient and secondary bacterial infection was suspected. Patients whose condition was severe (6.5% of the in-patients) were transferred to the ICU. There were no deaths. Two other studies of children hospitalized for kerosene poisoning, one with 205 patients²⁰ and the other with 140 patients,²¹ also reported no fatalities. However, investigations in India and South Africa have reported incidents of death, though usually at a low rate. Gupta et al¹⁰ reported a 4.3% mortality rate. Lucas²² recorded 3 deaths in his study of 526 patients, and Ellis et al⁴ also reported a low fatality rate (0.74%).

According to our study, there is a higher risk of hydrocarbon poisoning during the hot months of the year. The respiratory system was the main target organ in hydrocarbon poisoning. Pneumonia was mostly interstitial and bilateral. Vomiting after hydrocarbon ingestion affected the rate of pneumonia development. Symptoms of CNS impairment correlated with hypoxia, pneumonia,

and fever; however, CNS toxicity can occur without concurrent pulmonary or other pathology. In this study, the data were collected retrospectively and are therefore subject to errors of omission or incomplete documentation.

In conclusion, projects for the prevention of such poisoning incidents within the general population, especially within the Bedouin community, are definitely needed and should be implemented as soon as possible.

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