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Long-term Follow-up Study of Pulmonary Function Test in Children with History of Hydrocarbon Aspiration

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Abstract

Background
Aspiration of hydrocarbons causes several acute and chronic pulmonary complications; it may even lead to death. The aim of this study was to investigate the types of long-term pulmonary complications in children with a history of hydrocarbon aspiration.

Materials and Methods
In this case-control study, 21 children with history of hydrocarbon aspiration in the past 1-10 years were considered as case group, and 63 children without history of toxicity were regarded as the control group. The two groups were matched in terms of age and gender. Both groups underwent physical examination (such as height, weight and body mass index), and pulmonary function tests by spirometry. Pulmonary function was categorized based on three spirometric patterns, normal, obstructive, and restrictive. In addition, the baseline characteristics of children and information obtained from clinical and paraclinical examinations during poisoning were recorded in a researcher-made checklist. The obtained data were analyzed using SPSS software (version 16.0).

Results
The percentage of normal, obstructive and restrictive spirometric patterns were 61.89%, 28.58%, and 9.52% in the case group, and 88.88%, 11.11% and 0% in the control group, respectively ($P < 0.05$). In the case group, the results of spirometry test showed no association with the clinical signs and symptoms as well as the radiological findings at the time of poisoning ($P > 0.05$). The results of the pulmonary function test were not related to the time elapsed from poisoning ($P > 0.05$).

Conclusion
Based on the results, long-term hydrocarbon poisoning caused pulmonary dysfunction in terms of spirometric patterns in children.

Key Words: Aspiration, Children, Hydrocarbons, Poisoning, Pulmonary function.

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1- INTRODUCTION

Hydrocarbons are the main constituent of the fuels. Due to their daily usage, they can lead to accidental household or oral poisoning in children (1). Poisoning with these substances may cause major disorders in vital organs of the body, including depression, aggression, ataxia, headache, dizziness, nausea, hallucination, seizure, and syncope in the central nervous system (2). Their aspiration into the respiratory system can lead to fatal pneumonitis (3, 4), and certain respiratory complications such as asthma-like reactive airway syndrome, coughing, wheezing, respiratory distress, and hypoxia in the victims. In addition, other complications such as necrotizing pneumonitis, loss of surfactant, airway epithelial damage, damage to pulmonary capillaries and alveolar walls, and oxidative stress in the lung tissue, may eventually result in respiratory problems (1, 5-9). Hydrocarbon aspiration can even lead to death through respiratory failure (10). Inappropriate treatment for such complications can deteriorate the child’s condition (11).

Numerous studies have addressed the short-term complications of this type of poisoning (14-14), the long term pulmonary problems have been rarely studied. A comparison between the clinical and paraclinical observations related to the time of pulmonary poisoning and pulmonary function can provide an insight on the long-term pulmonary dysfunctions among these children even at the time of poisoning. Such findings can be helpful in diagnosis and follow-up of children with a potential for lung damage before they develop complications. Therefore, considering that there are still unexplained aspects about the pathophysiology and the long-term effects of hydrocarbon effects on the lungs (7), which influences the selection of an effective therapeutic approach (15), this study is aimed to investigate various long-term pulmonary dysfunctions in children with history of hydrocarbon aspiration in the past 1-10 years and assess its relationship with the signs and observations at the time of poisoning.

2- MATERIALS AND METHODS

2-1. Study design and population

In this case-control study, 21 children with history of episodes of hydrocarbon poisoning during the past 1 to 10 years were selected as the case group, and 63 age-and gender-matched children with no history of hydrocarbon poisoning were included as the control group.

2-2. Methods

The children in the case group were referred to Hajar Hospital in Shahrekord during 2017 to 2018 and the children of control group were students of the elementary schools in Shahrekord, Iran. All the children in the case and control group were selected by convenience sampling. Clinical examinations were performed on the patients to detect their current signs and symptoms. Then, using the MIR Spirolab New spirometric device, the pulmonary function test was conducted to collect data such as FEV1, FVC, FEV1 / FVC, FEF25-75%, FEF25%, FEF50%, and FEF75% before and after inhaling two puffs, equivalent to 200 µg, of Salbutamol spray (Ventalex, Sinadarou) as bronchodilator. The findings of the clinical examinations at the current referral and the data obtained from the pulmonary function test were recorded in a checklist. The results of the pulmonary function test were interpreted by a principal investigator according to the scientific reference, and then recorded into the checklist.

2-3. Measuring tool

The medical records in the Medical Records Unit of the hospital were reviewed to identify the children with the history of hospitalized after one or more incidence of hydrocarbon poisoning during the past 1-10 years. In addition, the individual characteristics of the patients (e.g. age, height, weight and BMI), their symptoms at the time of poisoning, pulmonary examination, and radiological findings at the time of poisoning were collected.

2-4. Ethical consideration

The study was approved by the ethics committee of Shahrekord University of Medical Sciences with the ethical code of IR.SKUMS.REC.1395.276. Before begining the study, the necessary explanations about the procedure of the study were presented to the children's parents, and then they were asked to sign a written consent form allowing their children to participate in the study.

2-5. Inclusion and exclusion criteria

The case group included all children with history of hydrocarbon poisoning in Hajar Hospital in Shahrekord city in the past 1 to 10 years. For each child in the case group, three age and sex-matched children were considered as control group. The inclusion criteria for the case group were: having developed hydrocarbon poisoning at least one year ago and having access to the child for examinations and spirometry tests in the hospital. An inclusion criterion for the control group was having no evidence of hydrocarbon poisoning and history of pulmonary disease before poisoning. History of atopy in the family, and the risk factors for pulmonary diseases such as inactive smokers were regarded as the exclusion criteria.

2-6. Data Analyses

Continuous variables were presented as mean ± standard deviation (SD), while the categorical ones were reported as frequency with percent. Normality distribution was assessed with the Kolmogorov test. The two groups were compared using the Chi-square test for categorical variables and independent T-test for continuous ones. Chi-square test was employed for comparison of spirometry patterns between the case and control groups; while the relationship between spirometry patterns with some clinical and radiological symptoms and findings was checked by Chi-square or Fisher's exact test. Statistical analysis was performed using SPSS software version 16.0 and p-value less than 0.05 was considered as statistically significant.

3- RESULTS

The children’s age ranged from 7 to 11 years with mean of 8.38 ± 1.3. Totally 76.19% of the children in both groups were boy. There was no significant difference in the age, height, weight and BMI of the two groups ($P > 0.05$) (**Table.1**). In the case group, 18 (85.71%), 2 (9.52%) children, and 1 (4.76%) child had the history of kerosene poisoning, gasoil poisoning, and gas poisoning, respectively. The spirometry pattern is present in the **Table.2**. None of the children in the control group had any restrictive spirometry. Statistical analysis showed that the spirometry patterns in the two groups were significantly different ($P= 0.005$) (**Table.2**). In the case group, 13 (61.90%) had normal pattern, while 6 (28.57%), and 2 (9.52%) children exhibited obstructive had restrictive spirometry patterns, respectively. In the control group, 56 (88.88%) had normal, and 7 (11.11%) had obstructive spirometry. None of the children in the control group had restrictive spirometry. Of the 16 boys in the case group, 10 boys had a normal pattern, 4 had an obstructive pattern, and 2 showed a restrictive pattern. Among the 5 girls in the case group, 3 had normal while 2 showed obstructive spirometry. According to Fisher's exact test, spiromety pattern did not have any relationship with gender ($P=1.0$). The relationship between the spirometry patterns and several clinical symptoms and radiological findings is presented in **Table.3** for the case group. Accordingly, spirometry pattern did not show any association with clinical signs and symptoms and radiological findings at the time of poisoning (P> 0.05). The time elapsed from poisoning until the study was in the range of 2-8 years with a mean value of 3.3 ± 1.8 years. The pulmonary function test did not indicate any significant association with the time elapsed from poisoning (P = 0.16).

Table-1: Baseline characteristics of children in two groups.

Variables	Control group, n=63	Case group, n=21	P-value
	Mean ± SD	Mean ± SD	
Age (year)	8.38±1.3	8.38±1.3	1
Height (Cm)	131.1±8.8	130.2±7.9	0.68
Weight (Kg)	26.7±7.2	27±6.5	0.89
BMI (Kg/m^2)	15.3±2.5	15.7±2	0.50

BMI: Body mass index; SD: Standard deviation. Control group: Non-toxicated; Case group: intoxicated.

Table-2: Spirometry patterns of case and control groups.

Groups	Patterns of spirometry			P-value
	Normal Number (%)	Obstructive Number (%)	Restrictive Number (%)	
Case (Intoxicated, n= 21)	13 (61.90)	6 (28.57)	2 (9.52)	0.005
Control (Non-intoxicated, n= 63)	56 (88.88)	7 (11.11)	0 (0)	

Table-3: Patterns of spirometry according to clinical symptoms and radiological findings during poisoning.

Variables	Level	Patterns of spirometry			*P-value
		Normal Number (%)	Obstructive Number (%)	Restrictive Number (%)	
Cyanosis	Yes	3 (14.28)	1 (4.76)	0 (0)	0.73
	No	10 (47.61)	5 (23.80)	2 (9.52)	
Vomiting	Yes	10 (47.61)	6 (28.57)	2 (9.52)	0.34
	No	3 (14.28)	0 (0)	0 (0)	
Cough	Yes	8 (38.09)	3 (14.28)	1 (4.76)	0.87
	No	5 (23.80)	3 (14.28)	1 (4.76)	
Tachypnea	Yes	5 (23.80)	3 (14.28)	1 (4.76)	0.87
	No	8 (38.09)	3 (14.28)	1 (4.76)	
Pulmonary stethoscope findings	Normal	6 (28.57)	5 (23.80)	1 (4.76)	0.56
	Crackling	5 (23.80)	1 (4.76)	1 (4.76)	
	Crackling + Wheezing	2 (9.52)	0 (0)	0 (0)	
Radiological findings	Radiography free	3 (14.28)	1 (4.76)	1 (4.76)	0.85
	Normal	3 (14.28)	2 (9.52)	0 (0)	
	Unilateral parenchymal involvement	1 (4.76)	1 (4.76)	1 (4.76)	
	Bilateral parenchymal involvement	1 (4.76)	0 (0)	0 (0)	
	Parenchymal involvement + Reduced lung volume	1 (4.76)	0 (0)	0 (0)	
	Parenchymal involvement + pleural effusion	2 (9.52)	0 (0)	0 (0)	
	Parenchymal involvement + hyper inflation	0 (0)	1 (4.76)	0 (0)	
	Patchy infiltration	2 (9.52)	0 (0)	0 (0)	
	Hyper inflation	0 (0)	1 (4.76)	0 (0)	

*Exact Fisher test.

4- DISCUSSION

Considering the controversial results of the studies and lack of any research evaluating the long-term pulmonary dysfunctions in Iranian children with history of hydrocarbon aspiration, the present study was conducted on 21 children with a history of hydrocarbon aspiration in the past 1 to 10 years and 63 age-and gender-matched children with no history of poisoning. In our study, the results of spirometry tests were not associated with any signs and symptoms and radiological findings at the time of poisoning. Spirometry results were not also associated with the time elapsed from poisoning. The percentage of normal, obstructive and restrictive spirometry was 61.89, 28.58 and 9.52%, in case group and 88.88%, 11.11% and 0% in control group, respectively ($P< 0.05$). Some studies have shown that lung damage and dysfunction may persist long after the hydrocarbon poisoning (16, 17); while in the study by Reed et al., no abnormal radiological findings and respiratory disorders were observed after several years of hydrocarbon pneumonitis (18). Taussig et al., also found no abnormal findings in pulmonary function or chest radiography 8 to 10 years after the hydrocarbon poisoning (19). The most important methods for pulmonary diseases diagnosis is the pulmonary function test, especially spirometry. The main patterns of ventilatory function include obstructive pattern, restrictive pattern, and lung dynamic volume and capacity including FVC and FEV1 (20). In the present study, the prevalence of restrictive and obstructive pattern was significantly higher in children with a history of hydrocarbon poisoning (compared to the controls). In a study by Tal et al. (21), 14 asymptomatic children were studied 10 years after their hydrocarbon pneumonitis. At the time of poisoning, eight children had abnormal chest radiographs and the remaining 6 showed normal chest radiographs. The findings of this study showed airway obstruction. Airway activity in sport test was normal in all the children. After 10 years, four children with abnormal chest radiography at the time of poisoning still had abnormal radiography. The researchers finally concluded that the subclinical and prolonged airway dysfunctions after the hydrocarbon pneumonitis period are associated with severity of the primary damage (21). Similar to the study of Tal et al., the obstructive patterns were observed in children with a history of hydrocarbon poisoning. The restrictive pattern was also observed. Besides, the results of the pulmonary function test were not associated with chest radiography at the time of poisoning, which may be due to the differences in the genetic responses of damage among the studied subjects. In the present study, the results of spirometry test were not associated with the clinical signs and symptoms. Consistently, in a study, X-ray results of 35% of patients with lung involvement with hydrocarbons did not show any problems related to lung involvement at the beginning of the study (22). A review article reported a scant relationship between clinical symptoms and radiography findings of the chest (12). But in contrast with these findings, in the study of Tal et al., four out of eight children had abnormal radiography 10 years after abnormal chest radiography at the time of poisoning (21). Such a difference can be due to the different in follow-up duration, types of aspirated hydrocarbon, and the difference in the studied populations in terms of the damage and response severity. Owing to their volatility, low viscosity and low surface tension, hydrocarbons can penetrate into the distal airways and affect a great part of the lung tissue (23-25). Repeated aspiration of hydrocarbons is one of the most important causes of pulmonary complications in the poisoning with these substances; even, oral ingestion does not directly damage the lungs (26). Aspiration causes direct damage to the lung parenchyma resulting in certain disorders such as hemorrhagic pulmonary edema, bronchospasm, direct inflammatory response, necrosis, pleural effusion, leukocytosis, hypoxia, subcutaneous emphysema, pneumomediastinum, and pneumothorax (3, 27-30). Therefore, subclinical and prolonged airway dysfunctions after the period of hydrocarbon pneumonitis seem to be associated with severity of primary damage, necrotizing bronchiolitis, necrotic epithelial cell damage, and alveolar destruction, leading to certain consequences such as reduced pulmonary ventilation capacity.

4-1. Study Limitations

This study was conducted to investigate long-term hydrocarbon poisoning and did not address the short-term pulmonary dysfunctions among children. Larger sample size is recommended in future studies.

5- CONCLUSION

Long-term hydrocarbon poisoning caused pulmonary dysfunction in terms of spirometric patterns finding in children. But the results of spirometry test were not significantly associated with the signs and symptoms and radiological findings at the time of poisoning. The restrictive patterns were higher in the case group (Intoxicated) than in the controls (Non-intoxicated). These findings suggest an investigation of children with a history of hydrocarbon poisoning, even if they are asymptomatic; such screenings could help in detecting the patients prior to development of serious complications in adulthood.

6- ABBREVIATION

FEV1: Forced Expiratory Volume in first second,
FVC: Forced Vital Capacity,
FEV1 / FVC: Forced Expiratory Volume in one second (FEV1)/Forced vital capacity (FVC),
FEF25-75%: Forced Expiratory Flow between 25% and 75%,
FEF25%: Forced Expiratory Flow-25%,
FEF50%: Forced Expiratory Flow-50%.

7- CONFLICT OF INTEREST: None.

8- ACKNOWLEDGMENTS

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