Hydrocarbon toxicity: an analysis of AAPCC TESS data

Toksyczność węglowodorów: analiza danych systemu rejestracji zatruć (TESS) Amerykańskiego Stowarzyszenia Ośrodków Informacji Toksykologicznej

Introduction: Human hydrocarbon exposures have the potential to cause significant morbidity and mortality. To determine which hydrocarbons were associated with the most severe adverse outcomes, human exposure data reported to American poison information centers were analyzed. Methods: Outcome data for single-substance, hydrocarbon exposures reported to the American Association of Poison Control Centers Toxic Exposure Surveillance System from 1994 through 2003 were analyzed. Only cases with definitive medical outcomes were included. Analyses were stratified by five age groups: <6 years, 6-12 years, 13-19 years, 20-59 years, >59 years. Hazard factors were determined by calculating the sum of the major effects and fatalities for each hydrocarbon category and dividing this by the total number of exposures for that category. To normalize the data, the overall rate of major effects and deaths for each age group was assigned a hazard factor value of 1. Hydrocarbon categories with a HF of >1.5 were included in the final analyses. Estimated rates of major effect and fatal outcomes (outcomes/1 000 people) were also calculated. Results: 318 939 exposures were analyzed. Exposures to benzene, toluene/xylene, halogenated hydrocarbons, kerosene and lamp oil resulted in the highest hazard factor values. Conclusions: These data demonstrate that hydrocarbons that are absorbed systemically and those with low viscosities are associated with higher hazard factors. The risks associated with hydrocarbons often implicated in abuse by older children and adolescents are also confirmed.

Table I
Hazard Factors and Estimated Major Effect and Death Rates, By Age Group*.
Czynniki ryzyka oraz ciężkie objawy zatrucia i współczynniki śmiertelności wyliczone dla poszczególnych grup wiekowych*.

*Shaded areas identify hydrocarbons with hazard factors > 1.5

Table II
Inhalation Exposure Hazard Factors and Estimated Major Effect and Death Rates in Children*.
Czynniki ryzyka oraz ciężkie objawy zatrucia węglowodorów Inhalacyjnych dla dzieci

*Shaded areas identify hazard factors of > 1.5

less than 6 years of age, accounting for 36.6% of exposures. Children in the 6-19 year-old category accounted for 12.9% of exposures. Hydrocarbon abuse was a common exposure reason in this group. Adults over the age of 19 years were involved in 49.3% of the exposures. Unintentional (not substance abuse or self-harm) exposures were responsible for 94.1% of the hydrocarbon exposures and 22.1% required treatment in a health care facility [5].

It is apparent from these data that hy-
hydrocarbon exposures represent a significant poisoning risk. Numerous scenarios for potentially toxic hydrocarbon exposures have been described including accidental aspiration by young children, inhalation abuse by older children and adolescents, and occupational exposure in adults [3,4]. There are numerous theories as to which hydrocarbons make them more hazardous. These include the hydrocarbon’s viscosity and surface tension properties.

The objective of this study was to calculate, by age group, the hazard factors (HFs) and the estimated major effect and fatality rates for hydrocarbon categories included in the AAPCC Toxic Exposure Surveillance System (TESS).

Methods
The AAPCC is a professional association that provides a forum for U.S. poison centers to address clinical toxicology issues, certify specialists in poison information, and conduct toxicological research. The TESS database is based upon the submission of data from member centers and provides other professional support services. All certified regional poison information centers are required to submit exposure data in real time to the TESS. The database was developed to analyze data so that poisoning exposures could be evaluated and profiled as a way to identify, prevent and treat poisonings. All data from the AAPCC TESS involving hydrocarbon product exposures were queried electronically for the period of 1994-2003 and supplied to the authors through a data grant from the AAPCC.

The data were prepared by an independent clinical scientist from the AAPCC who served in the capacity of an honest broker and provided the data electronically directly to the authors. Neither medical records nor individual patient-specific data were provided to the authors. Therefore, patient confidentiality was not compromised. Only exposures to a single hydrocarbon product were included in the analysis. Patient confidentiality was not compromised. Only exposures to a single hydrocarbon product were analyzed. Any poisoning exposure that involved exposure to multiple agents was excluded from analysis. Only age, clinical outcome and hydrocarbon name were analyzed. Sub-analysis was conducted for five age groups: 0-60 months, 6-12 and 13-19 year age groups, and greater than or equal to 60 years of age. Additional analysis was conducted for inhalation exposures. These seven subgroups were analyzed to determine medical outcomes. The following AAPCC TESS medical outcomes were used:

- Minor effect: The patient developed some signs or symptoms as a result of the exposure, but they were minimally bothersome and generally resolved rapidly with no residual disability or disfigurement. A minor effect is often limited to the skin or mucus membranes (e.g., self-limited gastrointestinal symptoms, drowsiness, skin irritation, first-degree dermal burn, sinus tachycardia without hypotension, and transient cough).
- Moderate effect: The patient exhibited signs or symptoms as a result of the exposure that were more pronounced, more prolonged, or more systemic in nature than minor symptoms. Usually, some form of treatment is indicated. Symptoms were not life-threatening, and the patient had no residual disability or disfigurement (e.g., cornmeal aspiration, acid-base disturbance, high fever, disorientation, hypotension that is rapidly responsive to treatment, and isolated brief seizures that respond readily to treatment).

Major effect: The patient exhibited signs or symptoms as a result of the exposure that were life-threatening or resulted in significant residual disability or disfigurement (e.g., repeated seizures or status epilepticus, respiratory compromise requiring intubation, ventricular tachycardia with hypotension, cardiac or respiratory arrest, esophageal stricture, and disseminated intravascular coagulation).

Death: The patient died as a result of the exposure or as a direct complication of the exposure. Only those deaths that were probably or undoubtedly related to the exposure are coded here.

Not followed, judged as nontoxic exposure: No follow-up calls were made to determine the outcome of the exposure because the substance implicated was nontoxic, the amount implicated was insignificant, or the route of exposure was unlikely to result in a clinical effect.

Not followed, judged as a potentially toxic exposure: Not follow-up calls were made to determine the patient’s outcome because the exposure was likely to result in only minimal toxicity of a trivial nature. (The patient was expected to experience no more than a minor effect.)

Unable to follow, judged as a potentially toxic exposure: The patient was lost to follow-up, refused follow-up, or was not followed, but the exposure was significant and may have resulted in a moderate, major, or fatal outcome. Unrelated effect: The exposure was probably not responsible for the effect.

Confirmed nonexposure: This outcome option was coded to designate cases where there was reliable and objective evidence that an exposure initially believed to have occurred actually never occurred (e.g., all missing pills are later located). All cases coded as confirmed nonexposure are excluded from this report.

The methods of Litovitz, and Manoguerra were used to calculate a hazard factor for each substance category [2]. For each exposure reason the hazard factor was determined by calculating the sum of the major effects (M) and deaths (D) and dividing this by the total number of reported exposures for each category and subcategory. For ease of comparison, each hazard factor was normalized to the overall rate (normalization factor = NF) of major effects and deaths for all cases in each exposure reason group. Only cases with definitive outcomes were included in the HF calculation. The overall rate of major effects and deaths was then assigned a hazard factor of 1. The following formula was used to calculate the hazard factor for each substance category and subcategory:

\[ \text{Hazard Factor (HF)} = \frac{\text{M} + \text{D}}{\text{NF}} \]

Estimated major effect and death rates per 1000 of population were also calculated. TESS data were compiled in SQL and hazard factors were calculated using Microsoft Excel 2002.

Results
See Tables I and II.

Discussion
Across all age groups, an average of 4.6 (28.8%) of the hydrocarbon categories had HFs ≥ 1.5. Interestingly, in the 20-59 age group, HFs were calculated in 8 of 16 (50%) hydrocarbon categories. These were distributed across aliphatic, aromatic and halogenated hydrocarbons and may reflect occupational exposures in this age group. Halogenated hydrocarbons and toluene/xylene had elevated HFs across all age groups with the exception of children < 6 years. These are consistent with the known systemic toxicities and known inhalation abuse patterns of halogenated and aromatic hydrocarbons.

For children less than 6 years of age, the HFs of 2.17 and 2.95, for kerosene and lamp oil respectively, are consistent with low viscosity aspiration risks associated with these hydrocarbons in this pediatric age group.

Inhalation exposures in the 6-12 year age group and 13-19 year age group were further analyzed given the high incidence of inhalation abuse in these age groups [1]. Over 4 000 inhalation exposures were reported in children in the 6-12 year age group. This translates to 19.7% of all hydrocarbon exposures that were analyzed in this group. In comparison, in the 13-19 age group 24.1% of analyzed hydrocarbon exposures were due to inhalation.

The findings of this study can be used by poison centers and other public health organizations to tailor-make their poison education and prevention programs. For example, in children less than 6 years of age, the risks that are associated with kerosene and lamp oil exposures are striking. In older children and adolescents, the known risks of abusing aromatic and halogenated hydrocarbons through inhalation are confirmed. The data in children in the 6-12 year age range are alarming in that they suggest that inhalation abuse of hydrocarbons occurs extensively in this younger age group. Again, poison centers, toxicologists, pediatricians and child care providers can use these data to guide the development of inhalant abuse prevention and education to targeted audiences.

Limitations of this study include aggregate analysis of hydrocarbon data without differentiation by exposure reason. Additionally, with the exception of sub-analysis of inhalation exposures in two age groups, the route of exposure was not analyzed. An inherent limitation of analysis of TESS data is the lack of verification of the exposure.

Conclusions
These data demonstrate that low viscosity hydrocarbons that are absorbed systemically, are associated with high hazard factors. The risks associated with hydrocarbons often implicated in abuse by older children and adolescents are also confirmed.

References