It Duke University Medical Center
Department of Community & Family Medicine
Division of Occupational & Environmental Medicine
Box 3834, Durham, NC 27710

January 17, 2017

A test methodology for determining aspiration hazards of aerosol sprays

Woodhall Stopford, MD, MSPH

Introduction

Aspiration pneumonia occurs with aspiration of hydrocarbons into the lungs and has been reported with accidental aspiration of kerosene in children and gasoline in adults. Aspiration can also occur with aerosol products that produce a ballistic stream or cone spray that can deposit large amounts of material in the back of the throat. Aspiration pneumonia has been described in children after intentional or accidental exposure to a ballistic stream pepper spray and death has occurred in at least one adult with a similar exposure (Olajos & Stopford, 2004). WD-40, a spray lubricant that can either be used as a cone spray or ballistic stream (the latter with an attachment) has also been implicated in aspiration pneumonia (Glynn & Gale, 1990). Hydrocarbons, ketones, and alcohols that can be aspirated are considered toxic products under Canada's Consumer Chemicals and Containers Regulations, 2001.

Gerarde (1963) found that placing 0.05-0.2 mL of a wide variety of hydrocarbons in the back of the throats of rats resulted in aspiration with increased mortality as long as the viscosity was less than 83 SUS at 100^{o} C. The lower dose is equivalent to 0.2 mL/kg or 2 mL per 10 kg child. At this dose that was a 10% death rate for kerosene with death rates ranging from 40-90% at higher doses. Using the same model, Gerarde and Ahlstrom (1966) found that aspiration of normal alcohols resulted in lung damage and death. Similarly Panson and Winek (1980) found that aspiration of 1mL/kg of a broad range of ketones resulted in death. Most of the deaths in this latter series were instantaneous indicating a systemic toxic effect.

Gerarde (1963) also investigated the toxicity of aspirating hydrocarbon aerosols. He sprayed 1 ml (4 mL/kg) in the back of the mouth in 2-3 seconds. No deaths occurred with aspiration of a kerosene aerosol and lung pathology was normal.
A
On 25 Oct 2001, CPSC amended the Poison Prevention Packaging Act to include the requirement for child-resistant packaging for consumer products that contain 10% or more hydrocarbons and have a viscosity of 100 SUS at 100^{o} F or less with exemptions for writing instruments and aerosol sprays. The original notice of proposed rulemaking said that only exempt aerosol cans provided that the "aerosol…expelled the product as a mist." CPSC noted, however, that they expected to address the "stream" vs. "mist" issue in a subsequent proceeding. Under Canada's Consumer Chemicals and Containers Regulations, 2001, spray containers must have child-resistant packaging if they would require such packaging as a liquid because of an aspiration hazard, unless "a spray container cannot be opened and dispenses the product as a mist."

This study develops a method that can be used to determine whether or not an aerosol container is dispensing a mist or stream and, further, looks at properties of aerosol products that are not steams but may present an aspiration risk similar to streams.

Equipment

Weights were measured with a scales calibrated with weights traceable to NBS-certified standards, one sensitive to 0.1 gm and the other to 0.0001 gm. .

Time was determined with a stopwatch, calibrated against NIST-traceable standards, measuring in 1/100ths of a second.

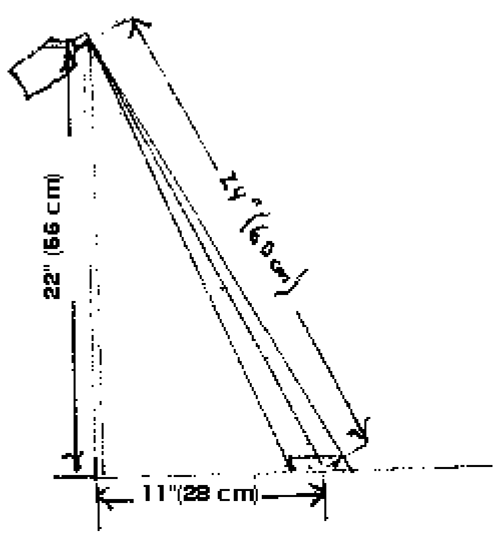
6.0 cm aluminum weighing cups (VWR, West Chester, PA)

Sticky wax (Rosenthal Jewelers Supply, Miami, FL)

Methods

Spraying was conducted at 20 ± 2^{o} C. in a draft-free room with ventilation turned off during spraying. Each spray aerosol was prepared as directed. If directions were not available, the can was shaken for 1 minute. Prior to each run, the spray aerosol being tested was discharged for 5 seconds. Weighing cups were weighed to the nearest mg before and within 60 seconds after each test. Each weighting cup was held in place on a Plexiglas surface with sticky wax. Spraying was done 24” (60 cm) from the target (see figure) for 5-7 seconds with the exact time of spraying determined by a stop watch. From this distance the target could be acquired within ½ second. A minimum of 3 tests were done for each test item. The Plexiglas surface was cleaned with VM&P naphtha between each test. Two determinations were made: the spray pattern (stream, mist or cone spray) and the weight of spray dispensed in the test cup/second. A stream spray was fully contained in the test cup, a mist did not fully cover the bottom of the cup and a cone spray was similar to a stream but less than ½ of the spray pattern was contained in the test cup.

Figure: Orientation of spray can to test cup



Results

Results are summarized in the table below. This method readily differentiated between the 3 spray patterns both by appearance and by the weight of spray deposited/second:

Spray pattern	range deposited/second (grams)
Stream	≥0.75
Cone spray	0.086-0.38
Mist	≤0.026

All of the cone-patterned sprays fully covered the test cups in each of the tests while none of the mists covered the bottom of the cups in any of the tests.

Product	**Deposition (gm/sec)**		**Spray pattern**
	Average	Peak	
Lubricants			
Power Lube*	0.75	0.86	stream
WD-40 (with tube)*	0.81	0.82	stream
WD-40 (without tube)*	0.38	0.39	Cone spray
Wasp spray (water-based)		6.15	stream
Varnishes			
Polyurethane Semigloss	0.026	0.043	Mist
Polyurethane Clear Satin	0.014	0.020	Mist
Matte Varnish	0.006	0.018	Mist
Paints			
Black	0.004	0.006	Mist
Brown enamel	0.086	0.090	Cone spray
Green enamel	0.157	0.168	Cone spray

*aspiration warning on label

Intralaboratory variation

The Power Lube product was tested 10 times with a relative standard deviation of 9%. Relative standard deviations for tests of other lubricants ranged from 0.9-5%. The relative standard deviation for 10 tests of an enamel was 4.6% and 3.8% for a second color. The relative standard deviations were greater for the mists. No difference in weights of test cups was seen in blank runs.

Discussion

Gerarde (1963) found lung damage and death when aspirating kerosene at an LOEL (lowest adverse effect level) of 0.2 gm/kg. When projecting risk from an LOEL level to a no adverse effect level (NOEL), uncertainty factors ranging from 3 to 10 are usually used. Using an uncertainty factor of 10, a cut off for aspiration concerns would be an amount of 0.02 gm/kg reaching the back of the throat or 0.2 gm for a 10 kg child of a petroleum distillate with a viscosity of 100 SUS at 100^{o} F or less. Using this point, the lubricants, either labeled for aspiration hazards or with known aspiration hazards (WD-40) would require labeling while for other aerosol products, this level is not exceeded. For one product, green enamel, the results are borderline and viscosity testing would be reasonable.

It appears that this test approach can reasonably differentiate between ballistic stream sprays and other aerosol products that may present a similar risk of aspiration, and those aerosol products that would not be expected to present this risk. Aerosol products that may have a similar risk to those of ballistic streams (such as WD-40 without a tube), deposit a similar mass of material on the weighing dish per unit time to the amount seen with ballistic sprays.

In addition to differentiating risk by weight, spray pattern is important. Gerarde's 1963 study showed that 20 times the LOEL value for liquid kerosene could be sprayed into the back of the throat as a fine mist with no risk of aspiration or lung effects: those aerosol products producing a fine aerosol would be expected to produce little if any risk. A similar pattern of spray types (ballistic stream, cone spray, fine aerosol) is also seen with personal protective devices and riot control agents (Stopford, unpublished data): the former 2 present risks of aspiration because of the large mass of liquid material that can deposit in the back of the throat.

It would appear that this method for determining spray pattern and spray deposition weight/second would be useful to support regulations that determine the need for child-resistant packaging of spray aerosols in both the US and Canada.

References

Gerarde HW. Toxicologiccal studies on hydrocarbons. IX. The aspiration hazard and toxicity of hydrocarbons and hydrocarbon mixtures. *Arch Environ Health*. 1963 Mar;6:329-41.

Gerarde HW, Ahlstrom DB. The aspiration hazard and toxicity of a homologous series of alcohols. Arch Environ Health. 1966 Oct;13(4):457-61.

Glynn KP, Gale NA. Exogenous lipoid pneumonia due to inhalation of spray lubricant (WD-40 lung). Chest. 1990 May;97(5):1265-6.

Olajos EJ, Stopford W., eds. Riot Control Agents. Issues in Toxicology, Safety and Health. London: CRC Press. ISB No. 0-415-29902-0. 2004.

Panson RD, Winek CL. Aspiration toxicity of ketones. Clin Toxicol. 1980 Sep;17(2):271-317.