

Childhood Burn Injuries Related to Gasoline Can Home Storage

Christopher S. Kennedy, MD* and Jane F. Knapp, MD‡

ABSTRACT. *Objective.* To examine the risks associated with home storage of gasoline and to outline prevention strategies to avoid further injury and death.

Design. Case series.

Patients and Other Participants. Twenty-five patients less than 6 years old were selected for study (3 by presentation to a tertiary care Children's Hospital Emergency Department, and 22 from the National Electronic Injury Surveillance System Data during the same calendar year).

Main Outcome Measures. Data collected included child's age; burn injury, either percent body surface area or minor, moderate, or major burn classification; mortality; circumstances related to ignition of gasoline, such as behaviors, and if can was opened or closed; and flame source.

Results. Boys were involved in 95% of cases. Mean age was 2.7 years. The source of ignition was a pilot light in 100% of cases. Forty-four percent of patients died. Only vapors were ignited in 56% of cases. The gasoline can was described as closed in 64% of cases.

Conclusion. Gasoline is dangerous. The rectangular red metal gasoline can is not safe either. National building codes and can specifications are needed to prevent serious injury and deaths among young children. *Pediatrics* 1997;99(3). URL: <http://www.pediatrics.org/cgi/content/full/99/3/e3>; gasoline storage, pediatric burn injuries, fire safety.

ABBREVIATIONS. NEISS, National Electronic Injury Surveillance System; CMH, Children's Mercy Hospital; ED, emergency department; USCPSC, United States Consumer Products Safety Commission; UL, Underwriters' Laboratories.

Gasoline is a near-perfect engine fuel. It has a high heat of combustion and a low ignition temperature. These same properties that make gasoline an excellent fuel also make it one of the most dangerous household substances. Gasoline is dangerous because it is highly volatile—the fumes are capable of ignition up to 12 feet away from a pooled source.¹ The inherent danger is further multiplied by its explosive potential. When ignited, gasoline vapors form a fireball with 10 times the heat released in the liquid

state.² One gallon of gasoline contains the explosive force of 20 sticks of dynamite.¹

A lack of understanding of the explosive nature of gasoline by the public seems to contribute to both its improper storage and misuse as a solvent, engine primer, and fire starter.³⁻⁷ This lack of awareness is perpetuated because current fire and burn prevention programs frequently do not include information about gasoline safety.³⁻⁷

Major burns sustained by five children in one summer prompted this retrospective study. Each case involved gasoline stored in red rectangular metal cans being tipped near a source of flame. These burn cases led us to review current storage standards for gasoline. In addition, the National Electronic Injury Surveillance System (NEISS) Data was examined to see if similar cases emerged.

METHODS

Five children presented to the Children's Mercy Hospital (CMH) Emergency Department (ED) between June and September 1990; three of these children were under 6 years old, one was 7 years old, and one was 11 years old. Each child had burns related to ignition of gasoline stored near a source of flame. To target the group at highest risk for nonintentional injuries, children less than 6 years old were chosen; thus, two CMH patients were excluded. Twenty-seven additional children less than 6 years old were identified using NEISS data for the calendar year 1990. Because each CMH case involved gasoline stored in a gasoline can, we focused on injuries related to this mode of storage. Only children with burns sustained when gasoline was stored in a gasoline can were included. Exclusion criteria included a history of storage in any other container eg, a paper cup, or in which no container description was available. Five NEISS cases were excluded on this basis. The 22 remaining NEISS children had sustained burns in mechanisms similar to our 3 patients. In all cases gasoline ignition was the primary source of injury. When combined with the CMH cases, these 25 children formed the sample for the study.

Variables for review included age (years), sex, percent body surface burned, depth of burn, circumstances relating to ignition, and deaths. Circumstances related to ignition included: identification and location of the flame source, any behavioral factors, whether the can was opened or closed, and whether or not vapors or liquid gasoline was ignited. Burn severity was defined using American Burn Association criteria.⁸

RESULTS

Data for all the CMH cases is presented in Table 1, and NEISS cases are presented in a similar format in Table 2.

Boys were involved in 95% of cases, and the mean age was 2.7 years. Ignition source was a pilot light in all 25 (100%) of the cases. Four fires were ignited by natural gas dryers, and 21 were ignited by hot water heaters. Eleven (44%) patients died as a result of their injuries. Vapors were ignited in 14 (56%) of 25 cases. The gasoline storage can was described as closed in 64% of the cases.

From the *Division of Emergency Medicine, Children's Hospital Medical Center of Akron, Akron, Ohio; and the †Division of Emergency Medicine, Department of Pediatrics, Children's Mercy Hospital and University of Missouri-Kansas City School of Medicine, Kansas City, Missouri.

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Reprint requests to (C.S.K.) Division of Emergency Medicine, Children's Hospital Medical Center of Akron, One Perkins Square, Akron, OH 44308-1062.

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TABLE 1. Children's Mercy Hospital Cases

Age	Sex	% Body Surface Area	2°/3°	Hospital Days	Mortality	Can Location	Ignition Source	Circumstance
16 month	Female	21	100%/0%	15 days/0 grafts	No	Basement	Dryer	Playing with closed can. Tipped can and fumes ignited.
2 year	Male	60	10%/50%	>60 days; first 7 on ventilator; five major procedures, debridement and grafting	No	Basement	Dryer	Lawn mower with closed gas can on top pushed down outside basement stairs. Hit natural gas dryer at bottom of stairs. Fumes exploded.
3 year	Male	95	0%/100%	Died after 8 days; fasciotomies, debridement	Yes	Basement	Dryer	Lawn mower with closed gas can on top pushed down outside basement stairs. Hit natural gas dryer at bottom of stairs. Fumes exploded.

TABLE 2. NEISS Cases

Age (mo)	Sex (M/F)	% BSA (if >20%) Major	Mortality	Can Location	Ignition Source	Circumstances-Fumes-Open/Closed
22	M	Major	No	Home	Water heater	Knocked over closed gas can, fumes ignited
36	M	Major	No	Home	Water heater	Closed gas can, spilled liquid gas ignited
24	M	Major	No	Home	Water heater	Climbed on a shelf, knocked over closed gas can, liquid ignited
24	M	Major	Yes	Washroom	Dryer	Uncapped gas can, fumes ignited
24	M	Major	Yes	Home	Water heater	Open gas can, spilled on clothes, ignited
24	F	Major	No	Home	Water heater	Closed can tipped, spilled liquid ignited
48	M	Major	No	Home	Water heater	Closed can tipped, spilled liquid ignited
24	M	Major	No	Home	Water heater	Playing with closed gas can, liquid ignited
48	M	Major	Yes	Home	Water heater	Kicked over open gas can, liquid ignited
24	M	Major	No	Garage	Water heater	Vapors ignited, closed gas can tipped
13	F	Major	Yes	Garage	Water heater	Vapors ignited, closed gas can tipped
24	M	Major	Yes	Garage	Water heater	Turned over closed can, liquid ignited
24	M	Major	Yes	Home	Water heater	Tricycle knocked over closed can, leaked gas, ignited
24	M	Major	Yes	Home	Water heater	Closed gasoline gas can tipped, liquid ignited
36	M	95%	Yes	Garage	Water heater	Gas poured from open can, vapors ignited
24	M	17%	No	Storage laundry	Water heater	Open gas can knocked over, vapors ignited 2 feet from pilot light
24	M	60%	No	Basement	Water heater	Closed can tipped over, vapors ignited
24	M	100%	Yes	Home	Water heater	Fumes from spilled open gas can, ignited
24	F	25-50%	No	Basement	Water heater	Open can, fumes ignited 10 feet away
48	M	25-50%	No	Basement	Water heater	Open can, fumes ignited 10 feet away
48	M	100%	Yes	Hallway	Water heater	Spilled open gas can, fumes ignited
2 years	M	25%	No	Utility room	Water heater	Closed gas can leaked when tipped, vapors ignited

Abbreviations: NEISS, National Electronic Injury Surveillance System; M, male; F, female; BSA, body surface area.

DISCUSSION

Gasoline-related thermal injuries account for 13 000 to 15 000 ED visits per year.³ Total gasoline-related injuries (ie, ingestions, inhalations, etc) by some estimates number 42 000 per year.⁸ Between 400 to 700 children are hospitalized annually with moderate to major gasoline-related burns (Minnesota Technical Institute, unpublished data, 1988). Two hundred fifty to 300 of these are children less than 5 years old.

Gasoline storage in the home presents a complex problem. Not only does it require a leakproof container, but also to use gasoline it must be transferred out of the container to the engine tank. The ideal mode of storage for gasoline would be intrinsically effective in preventing injury. Currently there is no single strategy available that is intrinsically safe. For this report we focus on the container and storage location in the home.

We chose children less than 6 years old for the study because they are a high-risk group for nonintentional gasoline burns in the home. This is related to widespread availability, poor storage practices, and the young child's inherent explorative behavior. At this stage of development they are totally unaware of the hazards gasoline introduces into their environment. Although older children and adults may misuse gasoline as an inhalant, solvent, or fire starter, children less than 6 years old do not do so with intention. Thus, when isolated by age, these children identify the risks that exist even when gasoline is stored in what is sold as a proper container.

The most frequently recommended container is the red metal gasoline can for 1- or 2-gallon amounts (see Fig 1). Upon closer examination, this container is usually rectangular, has top and bottom seams, and at least one side seam running the full height of the can. The spout is usually removable and inverted

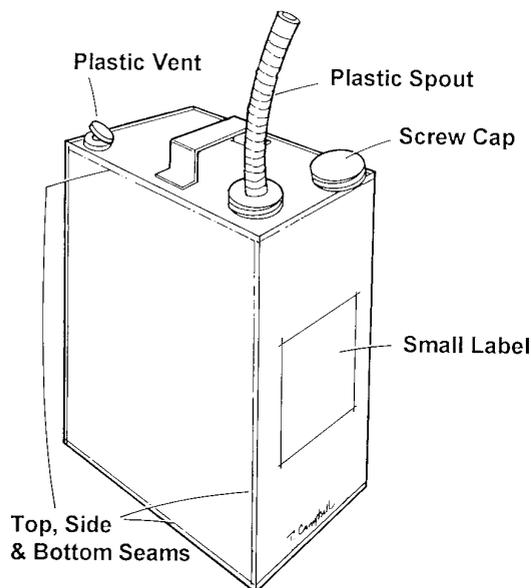


Fig 1. Structural elements of the standard rectangular metal gasoline can.

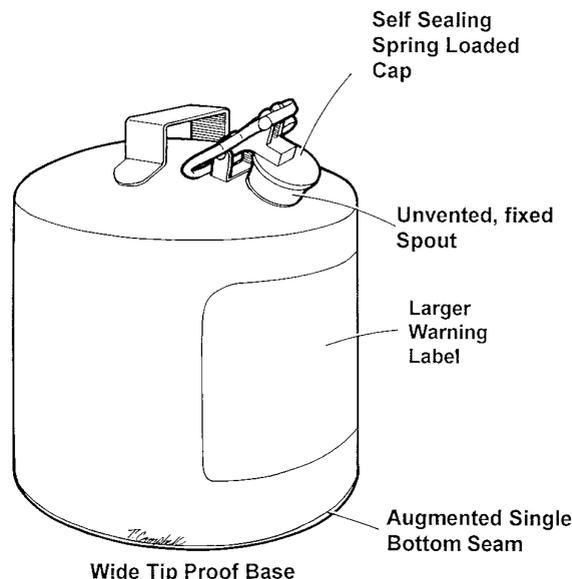


Fig 2. Structural advantages of a safety can.

into the can, replaced by a screw-on cap. Each rectangular can also has a vent, usually with a plastic cap.

There are no Occupational Safety and Health Administration standards for gasoline stored in small quantities in the home (less than 7 gallons) with regard either to storage location or can design. In the midst of the late 1970s gasoline shortage, concerns over the lack of standards for gasoline containers prompted an epidemiologic survey of gasoline can related injuries by the United States Consumer Products Safety Commission (USCPSC).⁷ The recommendations from this study were that standards be developed regarding can design. The standards describe a container which "... ought to be structurally sound, ought not to leak, either in storage or while gasoline is poured, and ought to be reasonably child-proof." At this point 48 states continue to have no container standards. Only Massachusetts and California have adopted container regulations that comply with the USCPSC recommendations for structural integrity. But they do not require containers to be child-proof, and do not address vapor leakage around spouts, seams, or vents.

All 25 children in this case review sustained thermal injuries related to can failure. In this study can failure is defined as a container that does not meet the USCPSC criteria outlined above. Although complete descriptions and manufacturers were not available, each of these injuries may have been prevented by using a safety can (Fig 2). This can design has many advantages over the red rectangular can. It utilizes a broad base with rounded top to be essentially tip-proof regardless of the amount of gasoline it contains. It has only a single seam around the bottom, which is augmented. The spout is fixed, thus, potential leakage points for either liquid or vapors are greatly reduced. Sixty-four percent of the cases presented were the result of closed cans being tipped with leakage around spouts or seams. A

safety can may have prevented these. In the remaining 36% of the cases cans were described as open. The safety can reduces this risk with a spring-loaded cap, also making it child-proof. To further prevent leakage of vapors, there is no separate vent. The lid is also self-sealing by means of a rubber gasket, so no vapors will leak out unless the lid is held open.

The safety can we describe here is tested and approved according to the Underwriters' Laboratories (UL) specifications. Only representative containers are tested, and although it is theoretically safer there are no data currently available regarding actual consumer use.

Although the focus here is on metal cans, plastic containers for gasoline storage are now widely available. It deserves mentioning that according to UL engineers plastics are inherently permeable to gasoline vapors. This permeability increases as the containers age. Although plastic technology has improved and permeability has been decreased, most plastic containers are actually tested and sold as temporary storage containers. This means that they are only intended for usage for 30 days or less, a fact that most consumers may not know.

The 1979 USCPSC report also references a letter from Dr Richard C. Miller, a professor of pediatric surgery at the University of Mississippi Medical Center, expressing concern about observed burn injuries caused by the ignition of gasoline by the pilot lights of gasoline water heaters located in the utility rooms adjacent to carports or garages.⁷ He was further concerned about the lack of building codes in his area prohibiting this practice. The USCPSC report corroborated this finding that gasoline water heaters are a common source of ignition for gasoline injury events.

Our data reiterates Dr Miller's concerns, as well as the USCPSC findings. The ignition source in 100% of our cases was a pilot light; 84% (21/25) were hot water heaters, and 16% (4/25) were from gas dryers. None were in secured storage locations, and all cans were within 12 feet of the flame source at the time of

the injury. Ignition of only vapors started the fires in 56% of cases. In the United States, regional variation exists in hot water heater placement. In warmer climates, hot water heaters are more apt to be in utility rooms, breezeways, or in the garage, increasing the likelihood of gasoline being stored nearby. Thus, in addition to problems with the container, storage location appears to be a consistent factor related to injury.

Children with gasoline burns have a high frequency of major injuries.^{5,6} Our study supports this finding; 88% of children sustained major burns and 44% died. This represents a higher mortality rate than for other burn injuries.

CONCLUSION

No injury is potentially more disfiguring, disruptive to a child's life, and more painful to endure than burn injuries. The horrific tragedy of each gasoline burn injury to a young child is magnified when it is considered that all he/she comprehends is the pain. Limited NEISS data were available for comparison of overall morbidity, however, each of the CMH cases presented demonstrates the severity of these injuries in individual pain and suffering. Burns this extensive require multiple surgical procedures, years of rehabilitation, and are costly economically.

Each of the cases presented appears to be an isolated event of unlikely circumstances, but when taken together striking similarities emerge. The most important of these similarities involve gender, can design, storage location, and burn severity. Fire safety courses and media coverage of gasoline-related thermal injuries seldom address issues related to storage. The general public and parents remain unaware of the danger and high-risk behaviors continue.

Currently there is no storage method intrinsically effective in preventing burn and explosion injury, similar to kill switches on lawnmowers or the airbag for motor vehicles. Despite education efforts, gasoline may still be stored near a pilot light. The most obvious prevention strategy would be to not store gasoline in the house and not within 50 feet of a pilot light. One alternative would be to sell prepackaged amounts of gasoline in a closed container that is made to be hooked up directly to the engine, as a replacement tank, similar to current practices for propane.

In this study we identify issues regarding the currently accepted safe practices for storage of gasoline; the most important of these are can design and storage location. Prevention strategies aimed at public education are not enough. The rectangular red metal can poses its own risks with leakage of vapor or liquid at seams, around spouts, and lids. They may tip over easily even when full. Although California and Massachusetts have can standards that address structural integrity, they do not go far enough. National can standards are needed. Currently a "safety can" is manufactured that combines a reduced number and augmented seams, a spring-loaded, self-sealing cap, and a broad, round base making it tip-, leak-, and child-proof. The major limitation of this can is the price, \$17, which is in part due to its low demand. In addition, simple building code modifications re-

stricting pilot light location away from storage areas such as garages or breezeways may prevent further injuries, save millions of health care dollars, and avoid years of painful procedures.

RECOMMENDATIONS

The Can

Uniform national standards are needed for gasoline can design. They should require that each can be approved. For approval each can should be leak-proof for vapors and liquid; unvented, with a fixed spout and spring-loaded, self-sealing cap; larger, clearer warning labels; and a reduced number of seams, each reinforced.

Storage Location

Gasoline should only be stored in a shed or garage in a locking cabinet, in a well-ventilated area. No pilot lights should be within 50 feet of the storage location, mandated by building codes where appropriate. Manufacturers of any household appliance that uses natural gasoline should place large warning labels that state clearly: "Do not store gasoline within 50 feet of this appliance."

Public Awareness

Media awareness and fire safety courses should increase the time devoted to gasoline storage practices, focusing on the dangers and safe practices. Educational material should be included with monthly utility bills from natural gasoline providers. They should include descriptions regarding the potential for danger and careful instructions for proper gasoline storage.

Physician Roles

Physicians should lobby their government to adopt standards at the local, state, and national levels. Patient and family education should be available at every well-baby visit.

ACKNOWLEDGMENTS

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REFERENCES

1. AAP Committee on Accident and Poison Prevention. McIntire MS, ed. *Injury Control for Children and Youth*. Elk Grove Village, IL: American Academy of Pediatrics; 1987;12:123-124
2. Williams II JB, Ahrenhale DH, Salem LD, et al. Gasoline burns: the preventable cause of thermal injury. *J Burn Care Rehabil*. 1990;11:446-450
3. McLoughlin E, McGuire A. The causes, cost, and prevention of childhood burn injuries. *Am J Dis Child*. 1990;144:677-683
4. Varas R, Carlbone R, Hammond JS. A one-hour burn prevention program for grade school children: its approach and success. *J Burn Care Rehabil*. 1988;9:69-71
5. Cole M, Herdon DN, Desai MH, et al. Gasoline explosions, gasoline sniffing: an epidemic in young adolescents. *J Burn Care Rehabil*. 1986;7:532-534
6. Klabacha M, Nelson H, Parshely P, et al. Carburetor priming: a cause of gasoline burn. *J Trauma*. 1985;25:1096-1098
7. Kale D, Mathers W, Harwood B. *Preliminary Analysis of Injuries Associated With Gasoline or Gasoline Container*. US Consumer Product Safety Commission Directive for Hazard Identification and Analysis; 1979
8. National Safety Council. *Accident Facts 1992 Edition*. Chicago, IL: National Safety Council; 1992;22, 96

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