

Suction-Type Suffocation Incidents in Infants and Toddlers

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ABSTRACT. *Objectives.* To describe the danger of upper airway obstruction associated with semirigid hollow objects in infants and toddlers and to define a minimum frequency with which episodes involving these products have occurred and propose a model defining the potentially hazardous characteristics of these objects.

Methods. A retrospective study of incidents reported to the US Consumer Product Safety Commission from January 1983 to March 2000, involving children younger than 5 years, was conducted. The medical literature (Medline) was searched for similar cases. The resulting case series was analyzed.

Results. A total of 17 incidents were identified in which a semirigid, hollow hemispherical/ellipsoidal object was described as having “cupped” the face, simultaneously covering the nose and the mouth. Of the 17 incidents, 13 involved toys; the remaining 4 incidents involved 2 different consumer products. All of these incidents involved children aged 4 to 36 months. Eight incidents resulted in death; 9 were nonfatal because of parental intervention. In all cases investigated, the infant was found with the semirigid object strongly adhering to his or her face. In 16 incidents, significant physical effort reportedly was required to remove the objects from the child’s face. The fatal incidents involved children aged 4 to 24 months, whereas the age range of the children in nonfatal incidents was 7 to 36 months. In all but 1 of the fatal cases, the victim was found dead in a crib or playpen. The cross-sectional diameter of the products involved in suffocation incidents was in the range of 6.4 to 9.7 cm. The depths of the products ranged from 4.2 to 5.1 cm. The approximate volume of containers ranged between 100 and 170 mL. These dimensions are compatible with the range of anthropometric measurements that allow the product to fit snugly over the mouth and the nose of a young child, resulting in complete airway obstruction.

Conclusions. Children between the ages of 4 and 36 months are at risk from suffocation by hollow, semirigid hemispherical/ellipsoidal objects through suction formation and complete airway obstruction. Shallow containers with dimensions ranging from approximately 6.0 to 11.0 cm seem to be especially hazardous. Several recommendations may be proposed to lessen the hazard to

young children. These include product design changes that limit the amount of contact with the perimeter and reduce the chance of forming a seal between the container and the face and ventilation holes to prevent a seal from forming. Although design change alone may be very helpful in products that are intended for use by children who are younger than 3 years, products that have similar dimensions and are not intended for infants present additional challenges. Thus, a very important additional prevention strategy is education. Pediatricians and other health care providers should alert parents and caregivers to the dangers of leaving such products in an infant’s crib or playpen or allowing infants to play with these objects while unattended. *Pediatrics* 2003;111:e12–e16. URL: <http://www.pediatrics.org/cgi/content/full/111/1/e12>; *suffocation, suction, hemispherical.*

ABBREVIATION. CPSC, Consumer Product Safety Commission.

Recent fatalities have brought attention to the hazard of semirigid hollow hemispherical/ellipsoidal objects forming an airtight seal over the nose and the mouth of infants and toddlers, resulting in upper airway obstruction and death by suffocation. Several different types of objects have been involved with incidents, including toys, components of toys, and containers (Fig 1).

In 1984, a company recalled a bowl-shaped stacking toy after it was involved in 1 suffocation fatality and 2 nonfatal suffocation incidents. In both cases, the object became attached by suction pressure over the nose and the mouth of the victim. The toy was hollow and hemispherical in shape. Three other incidents in 1990 involved one half of a hollow, nontoy container. In 1 case, a 7-month-old girl who had been placed in her crib overnight was found dead the next morning with one half of the container tightly sealed over her nose and mouth. In 2 separate nonfatal incidents involving the same product, a 12-month-old child and a 17-month-old child were found with the container adhering to the face.

In 1999, a 13-month-old was found in her playpen with half of a hollow plastic ball covering her airway. The victim’s mother reported that the object seemed to be held in place by suction. She pulled the object off the face, but the child could not be revived. One month later, another death involving the same product was reported: a 4-month-old suffocated in his crib after the half-ball became affixed over his nose and mouth. In a third incident, death was prevented by parental removal of the adherent half-ball. In these incidents, the hollow object was reported to have “cupped” the face, simultaneously covering the

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Fig 1. Sampling of products involved in the incidents reported in this study.

nose and the mouth (Fig 2). The product involved in each of these incidents was half of a semirigid plastic orbit measuring approximately 6.4 cm in diameter. The interior of the plastic ball was smooth and had no perforations. The product was part of a child's toy; it was a spherical container that was designed to separate into two hollow hemispheres when open. The product was recalled by the company in 1999.

These episodes highlight the hazard of semirigid hollow hemispherical/ellipsoidal objects forming an

airtight seal over the nose and the mouth, resulting in death by suffocation. They prompted a review of CPSC data to determine the contributory factors and better characterize the dangers of these objects to provide a foundation for improved product design and education.

METHODS

A search of the CPSC databases from January 1983 to March 2000 was conducted. The data search focused on facial suction and suffocation incidents (code 65) involving rigid or semirigid half spheres and children younger than 5 years. The data were derived from 3 databases maintained by the CPSC: Injury and Potential Injury Incidents; In-Depth Investigations,¹ and Death Certificates.²

The Injury and Potential Injury Incidents file contains incidents that are reported to CPSC through consumer complaint letters, electronic mail, and telephone calls; media articles; medical examiner reports; reports from fire and police departments nationwide; and referrals from other federal agencies. The In-Depth Investigations file contains In-Depth Investigations reports, which provide detailed information on the incident sequence and consequence. The Death Certificates file contains information from death certificates that the CPSC purchases from all 50 states and the District of Columbia. The deaths reported in these databases do not represent a complete count of deaths or a statistically valid sampling of known probability. The purpose of this study was to learn what is known about these incidents rather than describe their prevalence as a cause of death or injury in young children.

Although the data are unlikely to capture all of these incidents, particularly nonfatal episodes, the retrospective design and abbreviated nature of the descriptions that are available demonstrate a pattern of hazard and an "at risk" population. A Medline literature search was performed using the following terms: "suffocation," "airway obstruction," and "nose or mouth covered."

RESULTS

A total of 17 incidents in which a semirigid, hollow hemispherical/ellipsoidal object was described as having "cupped" the face, simultaneously covering the nose and mouth, were identified (Table 1). Of the 17 incidents, 13 involved toys; the remaining 4 incidents involved 2 different consumer products (Table 2). All of these incidents involved children aged 4 to

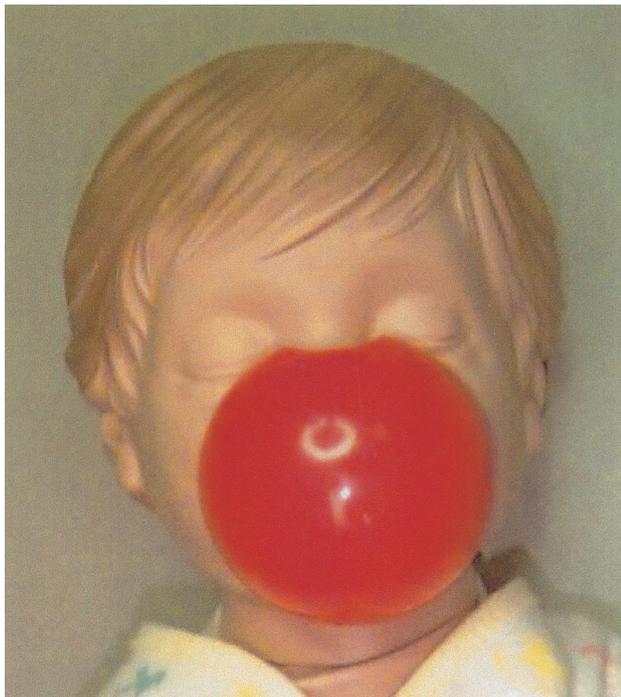


Fig 2. Product position on infant's face. This demonstration on a doll's face simulates how products may cover the nose and the mouth and lead to the suffocation incidents described in this study.

TABLE 1. Summary of Incidents

Date	Narrative/Outcome
10/19/83	A 4-month-old boy suffocated by the face of a doll as he slept in his crib. The face became detached and acted as a mask over the victim's nose and mouth. The infant died.
1/14/84	A 5-month-old girl was found dead in her crib with a cup-shaped head portion of a stacking toy over her mouth and nose. The infant died.
3/1/84	A 16-month-old boy temporarily lost his breath when the cup-shaped head portion of a stacking toy was held by suction over his mouth and nose. The victim's mother successfully removed the toy with force. No medical attention was needed.
11/13/84	A 14-month-old boy was found struggling, with the cup-shaped head of his toy stuck onto his nose and mouth. His mother had to break the vacuum by prying up the edge with her fingernails before she was able to remove the toy. The child was not injured.
2/8/85	A 7-month-old suffocated when half of a nontoy egg-shaped container became suctioned over the child's nose and mouth. The infant died.
6/11/85	An 18-month-old boy was uninjured when he placed a toy over his nose and mouth. The action of the infant's inhaling caused the toy to become stuck in place. His mother removed the toy. The toy was a plastic hemisphere.
5/18/87	A 4-month-old girl was asphyxiated when a plastic doll face obstructed her nose and mouth. The infant died.
3/7/88	A 17-month-old girl nearly suffocated after she got half of a plastic nontoy egg-shaped container stuck over her mouth and nose.
12/9/88	A 24-month-old girl suffocated while she was playing with a toy that she somehow got stuck over her mouth and nose. The infant died.
4/26/90	A 7-month-old girl nearly suffocated when 1 of the stacking cups she was playing with got stuck over her nose and mouth.
5/90	A 12-month-old girl nearly suffocated after half of a plastic egg-shaped nontoy container became stuck over her nose and mouth.
5/6/99	A 9-month-old girl was found not breathing with a container cap covering both her nose and mouth; she died in the emergency room. The infant died.
12/21/99	An 18-month-old girl nearly suffocated before her father pulled half of a container off her face. It became suctioned onto her face, covering her nose and mouth. On the second attempt, the girl's father pulled the half-ball from her face. She was examined by a physician and released. The container was part of a toy that was designed to separate into 2 hemispherical pieces when opened.
12/11/99	A 13-month-old girl was found lying unresponsive in a playpen. A white plastic piece shaped into a half-ball was found covering the child's nose, mouth, and chin. The container was part of a toy that was designed to separate into 2 hemispherical pieces when opened. The infant died.
1/25/00	A 4-month-old boy apparently suffocated when a plastic hemisphere, a container component, became lodged over his nose and mouth. The infant was found dead in his crib. The container was part of a toy that was designed to separate into 2 hemispherical pieces when opened. The infant died.
02/09/00	A 36-month-old girl was found unconscious in bed with a plastic hemisphere, a container component of a toy ball, covering her nose and mouth. Her mother was able to revive her. She sustained marks on her face for approximately 1 week. The container was part of a toy that was designed to separate into 2 hemispherical pieces when opened.
2/08/00	A 36-month-old girl almost suffocated from a container. The container was over the child's nose and mouth. The child's complexion was blue, and she was not breathing. The mother performed cardiopulmonary resuscitation and revived her. No medical attention was sought. The container was part of a toy that was designed to separate into 2 hemispherical pieces when opened.

TABLE 2. Suffocation Incidents: Dimensions of Containers and Victims' Ages

Product	Diameter (cm)	Height (cm)	Volume (mL)	Age (Months)
Container	6.4-6.9	4.2	100-120	7*, 12, 17
Cap	7.0	4.5	120	9*
Toy	8.9	5.1	170	5*, 16, 14
Toy	7.6	4.8	135	24*
Toy	6.8	4.5	106	4*, 13*, 18, 36, 36
Doll face	7.6	†	†	4*, 4*
Toy	†	†	†	7
Toy	9.7	†	†	18

* Child died.

† Unknown dimensions.

36 months. Eight of the 17 incidents resulted in death, whereas 9 were nonfatal because of parental intervention. In all cases investigated, the infant was found with the semirigid object strongly adhering to his or her face. In 16 incidents, significant physical effort reportedly was required to remove the objects from the child's face.

The fatal incidents involved children aged 4 to 24 months, whereas the age range of the nonfatal inci-

dents was 7 to 36 months. In all but 1 (infant was sleeping on the floor) of the fatal cases, the victim was found dead in a crib or playpen.

The cross-sectional diameter of the products involved in suffocation incidents was in the range of 6.4 to 9.7 cm. The containers were semirigid plastics with smooth continuous perimeters; they were not perforated. The depths of the products ranged from 4.2 to 5.1 cm. The approximate volume of containers ranged between 100 and 170 mL (Table 2). These dimensions are compatible with anthropometric measurements (Table 3) allowing the product to fit snugly over the mouth and the nose of an infant or toddler, resulting in complete airway obstruction.^{3,4} When descriptions or photographs were available,

TABLE 3. Relationship Between Facial Dimensions of Children 4 to 36 Months Old and Product Diameters

	Facial Dimensions (cm)	Product Diameter (cm)
Face length	6.1-8.3	6.4-9.7
Face breadth	8.5-10.9	

the imprint of the container's perimeter was visible on the victims' face, across the nasal bridge around the cheeks, and under the chin.

DISCUSSION

Several factors, including the developmental capacities and anatomic characteristics of young children, product characteristics, and product accessibility in an unattended environment, combined to result in the facial suction incidents reported in this study. It is likely that with the mouth and nose covered, an infant would be able to create suction or negative pressure necessary to maintain complete airway obstruction by gasping, sucking, or swallowing the volume of air in these containers.

The ability to create negative pressure is dependent on seal formation. For a seal to form between the face and the container, there must be continuous contact between the contours of the face (encompassing the nose and the mouth) and the outer edge of the rigid object. Seal formation is easier to achieve on a flat surface. The region of an infant's face between the chin and the zygomatic bone (upper cheekbone) presents a relatively flat surface where such contact can be achieved. A combination of facial features unique to infants, including a round face, easily compressible fleshy cheeks, and a small mandibular bone, may increase the area of contact and consequently increase the chance for a seal to form with the container. The anthropometric facial measurements of infants are compatible with the dimensions of the products.

Beginning at approximately 4 months of age, an infant's hand-to-mouth coordination improves. At this time, grasping becomes more precise, and thus objects within the child's reach have a good chance of being brought to the mouth. Teething begins at approximately 3 to 4 months of age and further encourages the bringing of hands and objects to the mouth. Also during this time, increased saliva production and excessive drooling⁵⁻⁷ are noted, which can facilitate the possibility of seal formation between the product and infant's face. Grasping in children younger than 4 months is imprecise, and, therefore, children younger than 4 months are not likely to be at risk for this hazard; this study did not find any reported cases involving infants younger than 4 months. The inability of an infant to remove an object adhered to the face either by grasping or coughing and the limited ability to seek help make them particularly vulnerable to the hazard scenario. There were no fatalities in children older than 36 months. Although a suction seal may be created in children of this age, danger may be lessened by their ability to break the suction seal themselves or to summon help.

All of the containers involved in the incidents were relatively shallow. The air in containers that are wider and shallower, such as the ones involved in the incidents, can be more easily suctioned out (displaced) than the air in containers that are narrow and deep. Thus, the effective volumes of the wider and shallower containers would be expected to be lower

because of the displacement of the air by the facial features of the infant. This displacement could then bring the remaining volume of air in the container to a level that could be depleted by the infant, thus creating enough negative pressure to form an airtight seal around the edge of the container.

A critical factor in these incidents is the child's access to the product in an unattended environment. In all but 1 of the fatal incidents, the object had been placed in the crib overnight or left in the playpen when an adult was absent for a period of time. Caregivers may perceive that an appropriately age-graded toy can be placed in the crib and left with an unsupervised child. This perception may extend to products that are not intended for infants but that present no apparent hazard (eg, a plastic container). In several of the incidents, the victim suffocated on an older child's toy or product intended for adults.

Finally, it should be noted that because none of the incidents was directly observed, there is no precise information about how the cup-shaped objects came to be placed over the infants' nose and mouth. The possibility of child abuse or infanticide needs to be assessed carefully whenever there is an unexpected death of a previously healthy infant or child. In all cases included in this analysis, the database records indicate that child abuse was eliminated as a factor after interviews with caregivers by the appropriate state investigators.

CONCLUSION

Children between the ages of 4 and 36 months are at risk from suffocation by hollow, semirigid hemispherical/ellipsoidal objects through suction formation and complete airway obstruction. Shallow containers with dimensions ranging from approximately 6.0 to 11.0 cm seem to be especially hazardous. An awareness of this hazard and the products involved is necessary among consumers, toy manufacturers, and the medical community.

Several recommendations may be proposed to lessen the hazard to young children. These include product design changes that limit the amount of contact with the perimeter and reduce the chance of forming a seal between the container and the face. The diameter of the product seems to be particularly important in this regard. Ventilation holes to prevent a seal from forming if the face becomes covered might lessen the chances of complete airway obstruction. Careful consideration and study must be given to the size, number, and placement of the holes for this to be an effective prevention strategy.

It is important to note that although design change alone may be very helpful in products intended for use by children younger than 3 years, products with similar dimensions and properties, for example containers for liquids, and products that are not intended for infants present additional challenges. It is not possible to anticipate which of those products may be given to infants and young children. Thus, a very important additional prevention strategy is education. Pediatricians and other health care providers should alert parents and caregivers to the dan-

gers of leaving such products in an infant's crib or playpen or allowing infants to play with these objects while unattended.

ACKNOWLEDGMENTS

We thank Signe Hiser, MS, for assistance in reviewing the databases. We also thank Mary Ann Danello, PhD, Lori Saltzman, MS, and Marilyn Wind, PhD, for review of the manuscript.

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Pediatrics 2003;111;e12
DOI: 10.1542/peds.111.1.e12

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