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TOY ASPARAGUS SPEAR RISK ANALYSIS

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ABSTRACT

A tragic accident occurred in a day care center when a 5 year old child fell face down with a plastic toy asparagus spear in his mouth, puncturing the soft palate and dissecting the internal carotid artery. Approaches utilized in the risk analysis include: literature review, safety standards research, accident statistics survey, biomechanical testing, and evaluation of alternative toy asparagus designs. The goal of this investigation is to make toy designers and users more aware of the puncture/impaling hazard and to identify design alternatives to prevent similar injuries from occurring.

INTRODUCTION

In the “home living” area of a day care learning center owned by the nation’s largest childcare company, a 5 year old boy was walking with a hard plastic toy asparagus spear in his mouth when he tripped and fell face down. The pointed asparagus tip punctured his soft palate and dissected his internal carotid artery. The subject 20.3 cm (8 in.) long asparagus spear shown in Fig. 1 and Fig. 2 was part of an assorted vegetable set that was marketed for dramatic play. The boy suffered a series of strokes as a result of blood clotting.

Following the subject accident, the day care center initiated a nationwide campaign to remove and destroy the entire vegetable set, including the asparagus spear from its 1,300 facilities in 39 states. In addition, the supplier of the vegetable set removed the asparagus spear from the inventory and requested that the manufacturer permanently remove the spear from future orders. Subsequently, the vegetable set continued

to sell well without the asparagus spear. Also, the green pepper’s stem was identified as needing shortening and rounding to eliminate any sharp points or edges.

The safety hierarchy [1] would suggest that attempting to eliminate the puncture/impaling hazard through design is the first priority. The manufacturer replaced the asparagus spear with a new design having a larger diameter, a more rounded tip, and a more flexible shaft as depicted in Fig. 3.

ACCIDENT STATISTICS

The U.S. Consumer Product Safety Commission (CPSC) has compiled accident statistics associated with children placing toy food in their mouth through the National Electronic Injury Surveillance System (NEISS) [2]. Narratives from the CPSC database from 1980 to 2004 describe injuries sustained by children mouthing toy food such as a candy magnet, a wooden watermelon piece, a toy fried egg, and a plastic fish. According to a 7 year (1987-1993) retrospective review of the urban pediatric trauma center registry at Cook County Children’s Hospital in Chicago, Illinois, falls were the most frequent cause of injury to children in the 0 to 5 year age group (43%) [3].

Based upon hospital admission data in Australia, it was estimated that for 1991-1992, the rate of fall injuries for zero to four year olds was 550 per 100,000 and the rate for five to nine year olds was 634 per 100,000 [4]. According to a different review of emergency department admissions of children in the U.S. from January 1986 through December 1987, more than 50% of oral injuries were the result of falls. It was reported that lacerations to the lip account for 62.8% of these injuries,

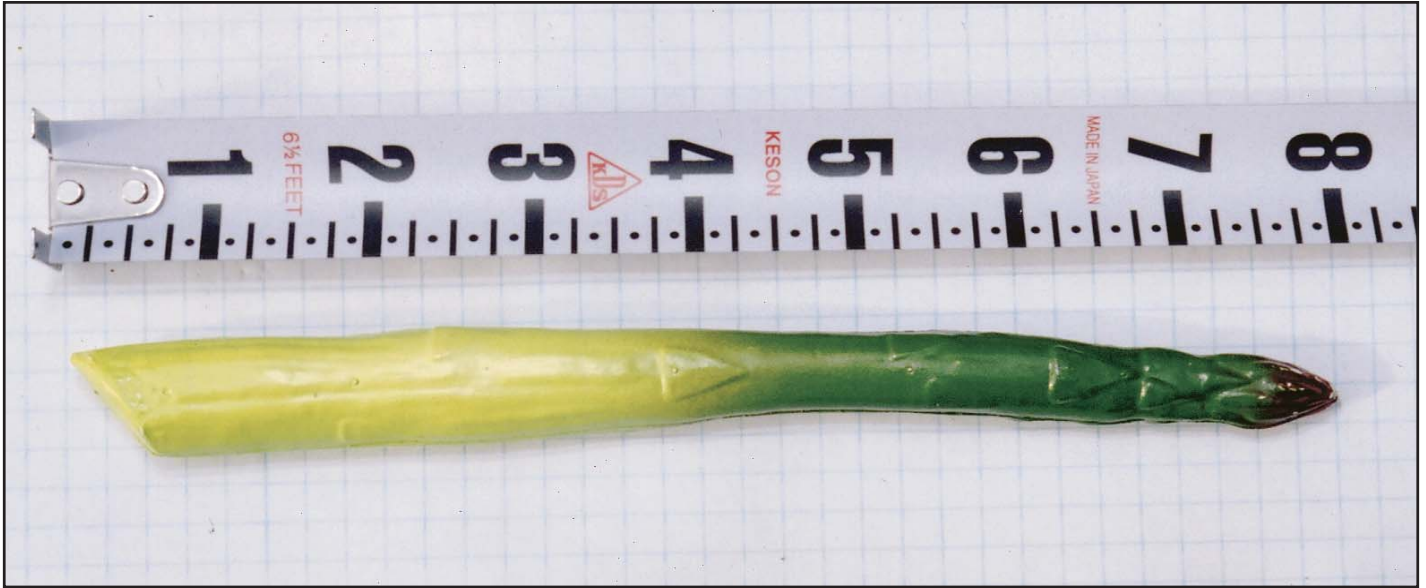


Figure 1 - Subject Toy Asparagus (Overall View)



Figure 2 - Subject Toy Asparagus (Close-up View)

followed by injuries to the soft structures of the oral cavity (12.7%). This survey found a peak in the number of injuries in the one to two year old age group [5].

According to 2001 U.S. hospital emergency department data, an estimated 17,537 children aged less than or equal to fourteen years old were treated for choking-related episodes for a rate of 29.9 per 100,000 population. Rates were highest for infants less than one year old (140.4 per 100,000) and decreased with age. The rate for children five to nine years old was 11.1 per 100,000. Of the 17,537 children treated in emergency departments, 59.5% were treated for choking on a food substance, 31.4% on a nonfood substance, and 9.0% on an undetermined substance. Food substances accounted for 2,355 choking related episodes among children aged five to fourteen years, 5,302 episodes among children aged one to four years, and 2,781 episodes among infants less than a year old [6].

The Department of Trade and Industry in the United Kingdom conducted research into choking hazards of children and found there was an average of 2,600 non-fatal cases a year between 1987 and 1996, and an average of 24 fatalities a year between 1986 and 1995. Eighty-two percent of non-fatal choking incidents involved children under three years of age, while 56% of choking fatalities involved children less than a year old. Toys were responsible for 6% and non-food items were responsible for 32% of the choking incidents to children under the age of four. Eighty-five percent of the incidents involving toys happened to children under three years old. Eight percent of the fatalities to children under the age of three were caused by non-food objects and 4% by toys or parts of toys. Sixty percent of the fatalities at all ages were caused by food items [7].



Figure 3 - Alternative Toy Asparagus

LITERATURE REVIEW

Previous studies have addressed injuries to children who were injured when their airways were obstructed by objects such as pen caps and a plastic toy snap-lock bead which became lodged in their throats [8, 9]. For this investigation, a review of the medical and safety literature [5,7, 10-23] was conducted to analyze penetrating/impalement injuries to the oral cavity in children. According to a case report and review of the medical literature performed by Belfer et al. [10], impalement injuries to the oral cavity are seen most often in young children ages 2 to 6 years old. Toddlers are at risk since they tend to carry potentially dangerous objects in their mouths for oral stimulation, and they also tend to fall easily because of their general lack of coordination. This case report describes a 25 month old male who fell while holding a plastic toothbrush in his mouth, impaling the bristle portion into his left posterior pharynx. The boy was unable to remove the toothbrush from his mouth. Some recommendations made in this study include the following:

1. All injuries to the parapharyngeal area should be considered potentially serious and the possibility of internal carotid artery thrombosis should be seriously entertained.
2. Parents should be educated to the potential dangers of infants and young children placing objects in their mouths, particularly while running.

Hellmann et al. [11] conducted a review of 131 cases of impalement injuries to the oropharynx/palate in children during the 17 year period from 1974 to 1990. Patient age ranged from

a newborn to 14 years with a mean age of 4 years. Males were injured almost twice as frequently as females. The left side of the palate was involved more frequently than the middle or right side. The higher incidence of left sided injuries may reflect predominant right-handedness among patients. The most common objects implicated were sticks, pens/pencils, cylindrical toys, and straws. The mechanisms of injury in decreasing order of frequency were:

1. Falling on an object carried in the mouth.
2. Direct force applied to an object being held in the mouth.
3. Falling or running into a stationary object with the mouth open.

Law et al. [12] provides a clinical review of two children with penetrating intra-oral injuries caused by toothbrushes. Both injuries, one to a 13 month old girl and the other to a 2 year old girl, occurred when the child fell with a toothbrush in her mouth. The authors feel that parents need to be made aware of the dangers of allowing toddlers to walk around with these objects in their mouths as the complications from these injuries can be so devastating. As a result, the authors have asked toothbrush manufacturers to place a warning on the toothbrush packaging and several leading companies have amended their packaging accordingly.

Research into the mouthing behavior of children up to 5 years old was commissioned by the Consumer and Competition Policy Directorate, Department of Trade and Industry (DTI) in London and published in July of 2002 [7]. Two hundred thirty-six children ranging from 1 month old to 5 years old were

observed in this study to investigate and quantify their mouthing behavior. This data can then be utilized to assess potential mechanical hazards, such as the puncture/impaling hazard, posed by the items which children were found to mouth. Table 1 displays the estimated daily mouthing time on all items mouthed. This table indicates that 5 year olds have an estimated mean mouthing time of approximately one hour. In the category of toy objects mouthed by children in the study, toy food ranked third. This study concludes that design and regulation should be used to ensure that those items which young children are guaranteed to come into contact with, and therefore mouth, do not present any mouthing hazards.

SAFETY STANDARDS

ASTM F 963-03

After the subject accident, an exemplar toy asparagus spear was submitted to TUV Rheinland of North America for testing according to ASTM F 963-03, Standard Consumer Safety Specification for Toy Safety [24]. The test results indicate that the asparagus sample fails to meet the requirements of the standard and presents an undue risk of injury when used by the intended age group of children. With reference to section 3.1.53 Reasonably Foreseeable Abuse, TUV remarks that the test sample presents a puncture/impaling hazard to the soft areas of the body or internal areas of the mouth and throat during the foreseeable misuse of putting the toy in the mouth and then falling on the sample in a horizontal and vertical configuration with the projection oriented up and down. Addressing section 4.8 Projections, TUV states that the projection presents an obvious puncture/impaling hazard which is unprotected and unmitigated. Regarding section 8.6 Abuse Testing, TUV indicates that the toy presents an undue hazard for impalement/puncturing during abnormal use. The risk assessment ranges from moderate risk to catastrophic risk depending on the soft part of the body impaled. In connection with section 3.1.31 Hazard, TUV recommends that the puncturing/impaling hazard can be mitigated by, for example:

1. Constructing the tip from flexible materials.
2. Constructing the tip to present a rounded top surface sufficient to prevent puncture penetration.
3. Constructing the shaft from more flexible materials.

EN 71-1:2001

Safety of Toys – Part 1: Mechanical and Physical Properties, European Standard EN 71-1:2000 [25] specifies requirements and methods of testing for mechanical and physical properties of toys designed or clearly intended for use in play by children less than 14 years old. Regarding section 5.9 Shape and Size of Certain Toys, TUV remarks that the toy asparagus spear protrudes past the base of the template A. This means that the toy asparagus fails to meet the geometric form requirements of the EN 71-1:2000 standard.

Federal Hazardous Act Regulations

According to the definitions section of the 16 CFR Part 1500 – Hazardous Substances and Articles: Administration and Enforcement Regulations [26], “hazardous substance” means any toy or other article intended for use by children which the Commission by regulation determines, in accordance with section 3(e) of the act, presents an electrical, mechanical, or thermal hazard. Furthermore, “banned hazardous substance” means any toy or other article intended for use by children, which is a hazardous substance, or which bears or contains a hazardous substance in such manner as to be susceptible of access by a child to whom such toy or other article is entrusted. An article may be determined to present a mechanical hazard if, in normal use or when subjected to reasonably foreseeable damage or abuse, its design or manufacture presents an unreasonable risk of personal injury or illness from, among other things, points or other protrusions, surfaces, edges, openings, or closures, or because of any other aspect of the article’s design or manufacture.

Table 1 - Estimated Mean and Daily Mouthing Time on All Items Mouthed (Hours: Minutes: Seconds)

Item Mouthed		Age Group											
		1-3 months	3-6 months	6-9 months	9-12 months	12-15 months	15-18 months	18-21 months	21-24 months	2 years	3 years	4 years	5 years
Total Estimated Mouthing on All Items	Mean	1:11:48	1:57:41	1:35:11	1:35:16	1:36:01	1:15:13	1:58:49	1:43:39	1:39:27	1:50:19	0:50:05	0:59:17
	Max	3:31:50	3:36:24	5:16:59	6:53:01	4:17:09	5:14:42	6:52:18	6:35:01	7:41:31	8:30:12	5:28:44	10:01:07

BIOMECHANICAL TESTING

Methods

A series of experiments performed by Hayes + Associates, Inc. (www.hayesassoc.com) were conducted at Oregon Health Sciences University (3181 S.W. Sam Jackson Park Road, L-477, Portland, OR 97201) to analyze the degrees of sharpness exhibited by 5 different objects. The 5 objects included: the subject toy asparagus, the alternative toy asparagus shown in Fig. 3, a plastic toothbrush, a chopstick, and a sharpened pencil (Fig. 4). The degree of sharpness was measured by recording the force required by each object to puncture a leather chamois (i.e. sharpness and force are inversely related). Leather chamois was chosen based on its suitability in simulating the human skin [27] and oral cavity [28]. An Instron Machine (Model #4442; Instron Corporation, 825 University Ave., Norwood, MA 02062) was used to press each object into a leather chamois, at a constant rate of displacement of 500 mm/min (19.7 in./min). Three tests were performed with each object, for a total of 15 tests.

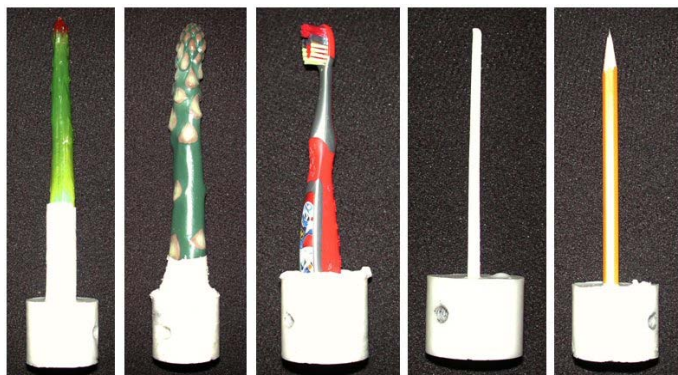


Figure 4 - Photographs of the Five Objects Tested (PMMA Bone Cement Shown)

Results

The pencil required the least amount of force 20.9 ± 6.7 N (4.7 ± 1.5 lb) to puncture the chamois, and was therefore considered to be the sharpest object tested (Fig. 5). The subject toy asparagus was determined to be sharper than the chopstick, but not as sharp as the pencil. The alternative toy asparagus and the plastic toothbrush failed to puncture the leather chamois, and instead buckled as the force was increased. Therefore, for these objects which buckled, the maximum force was recorded while the tip of each object remained in contact with the chamois. In comparing the two different toy asparagus designs, the sharper tip and more rigid shaft associated with the subject asparagus allowed it to successfully puncture the chamois (Fig. 6), while the alternative asparagus instead buckled (Fig. 7).

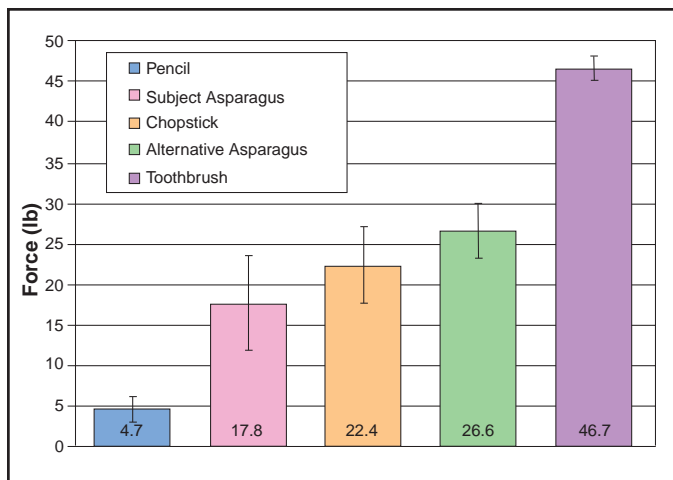


Figure 5 - Puncture Force Results (Ave ± SD)

ALTERNATIVE TOY ASPARAGUS DESIGNS

According to the safety hierarchy, the first priority is to eliminate the puncture/impaling hazard by removing the asparagus spear from the toy vegetable set as was done by the manufacturer following the subject accident. The second priority of the safety hierarchy is to apply safeguarding technology. As recommended by TUV, the puncture/impaling hazard can be controlled by rounding the asparagus spear top surface or making the tip and shaft more flexible. Figure 3 depicts an alternative toy asparagus spear which embraces these construction characteristics. The third priority of the safety hierarchy is to use warnings. This can take the form of warnings similar to those found on toothbrush packaging.

CONCLUSIONS

Four years before the subject accident, the former day care center education director and then toy asparagus supplier senior manager for education and training conducted a product review. Products that included a drum stick such as a xylophone were removed from the infant and toddler section (ages birth through 3 years old) of the catalog for safety reasons as the stick end presented a puncture hazard to the upper palate. At the same time, the U.S. Consumer Product Safety Commission (CPSC) and 15 firms announced the recall of more than 19 million swimming pool rigid plastic dive sticks which create an impalement hazard when children fall or land on them in a vertical orientation [29]. As of November 2000, the CPSC was aware of 9 confirmed impalement injuries involving submerged vertically standing dive sticks. All the victims were children ranging in age from 3 to 9 years old. Furthermore, the CPSC issued a rule to ban certain dive sticks that are rigid, submerge to the bottom of a pool of water, and stand upright in water under the authority of the Federal Hazardous Substances Act [30]. According to the CPSC Human Factors Staff, "because



Figure 6 - Photographs of Subject Asparagus Pre- and Post-Puncture



Figure 7 - Photographs of Alternative Asparagus Pre- and Post-Buckle



Figure 8 - Recalled Swimming Pool Dive Sticks

the stick is braced against the floor, the impact causes a relatively rapid deceleration of the body part which is struck, with the force of the impact concentrated on the small area at the end of the stick." Figure 8 depicts recalled dive sticks which fail to meet the CPSC safety requirements [31]. The dive sticks shown in Fig. 8 are about 19.1 cm (7.5 in.) long and 2.54 cm (1 in.) in diameter. The CPSC recommended using a softer or more flexible plastic as a design alternative to control the dive stick impalement danger [30].

Toy fruit and vegetable sets are a staple in the child educational supply industry. The purpose of toy vegetables is to simulate real vegetables when children are playing house. Teachers at the subject day care center indicated that the kids would quite often step over the line between reality and fantasy by pretending to eat the vegetables. The teachers said they had to sanitize the vegetables often because they were mouthed by the children. Realistic appearance of the toy asparagus spear in terms of its color and construction is an important consideration according to the day care center director of procurement systems. Given that it is reasonably foreseeable that young children will put toy food in their mouths and fall, more closely simulating a real asparagus spear in terms of its flexibility would, ironically, have prevented this calamitous event.

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