MEETING PLAN

FIRM: Riva Sport   Aqua Sling (water balloon slingshot)

DATE: May 17, 1995

ATTENDEES: Firm - Brock Landry, Esq (Jenner & Block)

CPSC - Jean Kennedy, Marc Schoem, Mike Gidding, Eric Stone, George Sweet HF.

PURPOSE: Discuss CAP; Firm agreed to discuss"improved warnings"

I. INTRODUCTION/BACKGROUND

Happy you're here on behalf of Mr. Jacobs
In light of injuries - we sent you
To discuss how to warn as many users as possible
Of the potential for some serious injuries with the two Aqua
KNOWING HOW DIFFICULT IT IS TO GET PEOPLE"S ATTENTION and TO CHANGE THEIR PERCEPTIONS, and then their behavior!

Know you have discussed with me and Mike that we're dealing with:
Nature of the product: slingshot at people with water.
Injuries occurring because: speed, perception of no risk.

15 cases injuries = where behavior shows no perception.
injuries = eye - severe, loss of vision, eye
neck - paralysis
cardiac arrest - unk brand,possible]

II. SOLUTION: How to overcome the perception through strong words.

I.E.= Strongest poss label on product, packaging and any other ways to alert public

THEIR = CHANGE A FEW WORDS ON LABEL.
ACCEPT OUR LABEL WITH SOME CHANGES.
NOT CHANGE PLACE.
OUR LABEL AND LOCATIONS.

SECOND BEST= on product where always visible.
on instructions (discarded).

III. NEXT ACTIONS: (What, When, Who)

Fax ANSI

Response - next week

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MICHELE SNOW FOUNDATION
3569 Paine Drive
Riverside, CA 92503
— (714) 354-7355 —

8/11

Dear Lee,
Hope this finds you well. FYI —
The latest BS —
Balloon Sling Shots
Lots of people getting hurt.

Take Care
Dave

Office Hours
9:30 am To 4:45,
Chicago

JAMA

The Journal of the American Medical Association

106 Years of Continuous Publication

JAMA, The Journal of the American Medical Association (ISSN 0098-7484), is published four issues per month by the American Medical Association, 535 N Dearborn St, Chicago, IL 60610. Phone (312) 645-5000. Cable address "Medic" Chicago.

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October 7, 1988, Vol 260, No. 13

To promote the science and art of medicine and the betterment of the public health.

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Sir Matthew Smith, *Peaches* 1900
M. T. Southgate, Chicago

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Zinc in Human Immunodeficiency Virus Infection
J. D. Shoemaker, M. C. Millard, P. B. Johnson, Urbana, Ill; J. Falutz, C. Tsoukas, P. Gold, Montreal

HIV-1 Antibody Testing L. W. Kitchen, New Orleans

Border Hopping as a Consequence of Premarital HIV Screening: The Kenosha Diamond
E. A. Belongia, J. M. Vergeront, J. P. Davis, Madison, Wis

Water Balloon Orbitopathy J. B. Holds, R. L. Anderson, M. Teske, Salt Lake City

Responsibility to the Patient and to the Patient's Impaired Physician J. M. Miller, Baltimore

Coming in *JAMA*—The Harvard Resource-Based Relative Value Scale (RBRVS)

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The Medical Care Costs of Human Immunodeficiency Virus–Infected Children in Harlem 1901
J. D. Hegarty, E. J. Abrams, V. E. Hutchinson, S. W. Nicholas, M. S. Suarez, M. C. Heagarty, New York

Medically Unnecessary Hospital Use in Children Seropositive for Human Immunodeficiency Virus 1906
K. Kemper, B. Forsyth, New Haven, Conn

Effects of Prophylactic Lidocaine in Suspected Acute Myocardial Infarction 1910
S. MacMahon, R. Collins, R. Peto, Oxford, England; R. W. Koster, Amsterdam; S. Yusuf, Bethesda, Md

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testing also has discou d many couples from complying with the Illinois law. In Wisconsin there has been an increasing number of marriage licenses issued to Illinois residents. During the first quarter of 1987 there were 87 marriages in Wisconsin in which both the bride and groom were Illinois residents; in the first quarter of 1988 there were 418 marriages among Illinois residents, representing a fourfold increase. During the same interval, the number of marriages performed for couples who both reside in Wisconsin declined slightly from 4149 in 1987 to 3926 in 1988 ($P<.002$, χ^2). This phenomenon is particularly prominent in southern Wisconsin: 74% of all marriages in the first quarter of 1988 to Illinois couples occurred in five Wisconsin counties that border Illinois. In these border counties, the number of Illinois residents getting married increased from 53 in the first quarter of 1987 to 306 in the first quarter of 1988 (Figure). Public health officials in other states that border Illinois have noted similar trends (Sara Edwards, AIDS Education Program, Iowa Department of Public Health, personal communication).

Other organizations are taking advantage of the increased interest in matrimonial border hopping. On May 14 the Kenosha (Wis) Twins sponsored a mass marriage before a class A minor league baseball game with the Rockford (Ill) Expos. Thirteen couples, including 11 from Illinois, participated. The ceremony took place on a Kenosha ballfield, with the theme "you supply the bride, and we supply the diamond." Individual and group marriage ceremonies involving Illinois residents may occur with increasing frequency in Wisconsin and other states bordering Illinois as long as the Illinois requirement for compulsory premarital HIV testing is in effect.

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James M. Vergeront, MD
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Wisconsin Division of Health
Madison

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Report of a Case.—The patient, a 23-year-old man, was injured while attending a university football game in October 1987. He was struck in right orbit by a water balloon launched by a giant slingshot located more than 300 m from the stadium and he suffered transient loss of consciousness. He was taken to a local emergency department, where extensive orbital fractures, lid ecchymosis, and loss of vision in the right eye were noted; the patient then was transferred to our care.

Initial examination was remarkable for an acuity of count fingers at .9 m in the right eye, 20/15 in the left. A 15% layered hyphema was noted in the right eye. Fundus examination showed a layered vitreous hemorrhage inferiorly and a marked amount of traumatic retinal edema. Coronal computed tomographic scans showed large orbital blowout fractures of the right orbital floor and medial wall as well as a fracture through the low-lying lamina cribrosa.

The patient was treated medically for the hyphema (which resolved spontaneously) and was followed up for a cerebrospinal fluid leak. As orbital swelling resolved it became apparent that the patient had marked (>5 mm) enophthalmos on the right side as well as marked entrapment of the inferior and medial rectus muscles by the orbital fractures. An orbitotomy was performed, with repair of the orbital fractures two weeks after injury.

At a three-month follow-up visit, the patient was noted to have an afferent pupillary defect with mild optic pallor and a macular hole on the right side, with visual acuity limited to 20/300. The globe position improved without noticeable enophthalmos or restriction of ocular motility, but constant diplopia forces the patient to wear an eye patch.

Comment.—The classic orbital blowout fracture is produced by a blunt object larger than the orbital rim impacting the orbit, with hydraulic compression of the orbital contents and fracturing of the thin bone of the orbital floor and/or medial wall. Enophthalmos and restriction of ocular motility are common late sequelae from the expansion of orbital volume and entrapment of extraocular muscles. The eye may suffer serious injury in conjunction with a blowout fracture. The proximity of the intracranial space, separated by thin, bony walls, raises the possibility of neurosurgical complications from an orbital injury. We have termed this previously unreported cause of orbital injury *water ballon orbitopathy.*

Since the submission of this report, a second case has come to our attention. A student riding on the hood of a car was struck in the face by a water balloon thrown from a passing car, producing a right orbital blowout fracture tha quired surgical intervention.

John B. Holds, MD
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1. Svenson J: A physician's dilemma. *JAMA* 1988:
2. *Darling v Charleston Community Memorial* 211 NE2d 253.
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How should physicians be paid good is the RBRVS?

The nine definitive peer-review ticles of the Hsiao studies and editorials will be in the Oct 28, issue of *JAMA*.

Don't miss them.

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from discoveries made by this faculty."

Lerner, whose institute receives more research funds from the National Institutes of Health than any other private organization, believes this cliffside has become a sort of shrine to research. "Here are the results of three separate visions: Revelle's, Salk's, and ours. You could hardly put three such institutions in sight of each other and lose the game."

One big winner was Hybritech, a biotech firm begun in 1978, just across the avenue. It was the first drug company to market monoclonal-antibody technology, developed to treat certain forms of cancer. As chief executive, Ted Greene, 46, negotiated Hybritech's sale in 1986 to the pharmaceutical giant Eli Lilly for 480 million dollars. When 800 employees divided 80 million dollars of the sales price, San Diegans grew curious about biotech. So far the city's 70 commercial biotech firms employ only about 2,700 people. Those attached to Scripps and smaller research groups double the number.

"San Diego has this appetite for risk taking," Greene said, guiding me among white-coated scientists in their labs. "Even the city's lack of social roots is productive. People are used to trying new things. In biotech this is like the Texas Panhandle in the 1920s and '30s. We are the wildcatters, waiting for the corporate giants to step in when scientists hit it big."

RAY DITTAMORE, 46, a native San Diegan, returned in 1982 after five years in Europe and noticed how the city's pace had changed.

"I found a different breed of young people," he told me. "If I wanted to see them, it wouldn't be over some long lunch. It was for breakfast or a quick sandwich at the office or racquetball after work. A new work ethic, a new commitment had swept the city."

Newcomers have accelerated cultural change. William Jovanovich, one of the more innovative New York book publishers, startled competitors by moving five book divisions to San Diego in 1980 and establishing his own home here. "I came out of sentiment," he told me. "I love this city." At offices in downtown San Diego, 400 of his employees edit and publish all the books of Academic Press, the largest U.S.-based scientific publishing firm, along with 95 science journals.

Even the San Diego Zoo and the Wild Animal Park are frontiers for science. Deep in Balboa Park, near its theaters, museums, gardens and galleries, are the laboratories of CRES, the Center for Reproduction of Endangered Species. Research Director Werner Heuschele and his colleagues use their findings to help troubled species such as cheetahs, gorillas, Chinese monal pheasants, and white rhinos. The Wild Animal Park hatched the first California condor chick in captivity. "There are only 30 of these great birds left," Dr. Heuschele said. "But now two others may be on the way. Some of the birds raised here will be released in the wild."

Other nations turn to CRES. It has helped breed Przewalski's horses, which had disappeared from their habitat in the Gobi desert

TWICE WINNER of the America's Cup for the San Diego Yacht Club, Dennis Conner may yet witness the forfeiture of sailing's most prestigious prize if courts ultimately rule that his catamaran, Stars & Stripes, *gave him an unfair advantage in the 1988 races. Also at stake: the estimated 1.4 billion dollars San Diego stands to gain for hosting the next regatta.* ***Many San Diegans are happy to pursue their own competitions. Racing off Point Loma, a mischievous crew launches water balloons at foes.***

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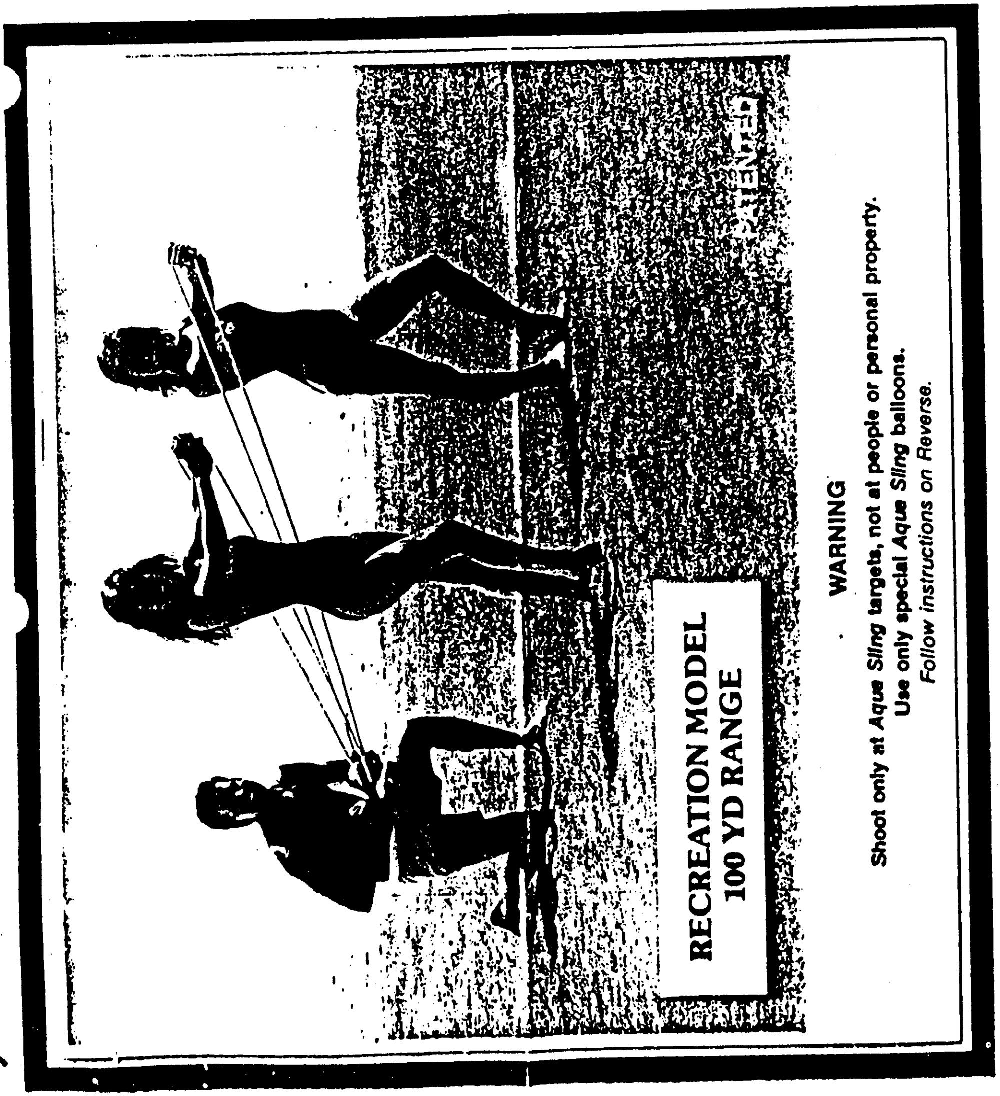
AQUA SLING
WATER BALLOON SLING SHOT

PATENTED

MADE IN U.S.A.



Use Only Special Aqua Sling Balloons & Targets

© 1987

One Person Operation:
Face target, hold one grip in each hand. Loop pouch handle under right toe, tension tubing. Place water balloon in pouch on top of toe. Stretch tubing over-head with both hands (make sure pouch handle does not slip out from under toe). Step forward with left foot, at same time extend both up-raised hands (holding grips) forward. Balloon pouch will release from under foot sending balloon toward target.

Three Person Operation: Recommended as Safest and Most Effective Technique
Two (2) holders stand two feet apart facing target, each firmly grasping one sponge grip of the Aqua Sling with their inside hand, stretching toward target at shoulder level until arm is fully extended. Launcher will stand between and behind the holders, firmly grasping the pouch handle with one hand while supporting the balloon in the pouch with the other hand. The launcher will pull back, aim, and let fly.
Note: Fill balloons to size of tennis ball for best results. (Over-filled balloons can explode when launched.)

WARNING! *WARNING!* *WARNING!*
Property damage and serious injury can result from improper use.
Follow instructions, use discretion, and have fun.

1. The Aqua Sling is an adult toy made for the sole purpose of launching Aqua Sling Balloons at Aqua Sling Targets.
2. Use only Aqua Sling supplied targets. Never shoot at people, animals, or personal property. Please use responsibly.
3. The Aqua Sling is most accurate/safe when used by three people.
4. Never stretch tubing more than six feet when launching balloons.
5. Always be certain that tubing connections are secure.
6. Never use Aqua Sling if there are signs of wear/tear.
7. Holders should not insert hands between tubing and sponge grip (grasp sponge grip and tubing together in one hand)

AQUA SLING, P.O. BOX 20404, SAN DIEGO, CA 92120

DISCLAIMER

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BEACH PADDLE SET
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SPALDING

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FAMILY SOFT TOUCH DART GAME SET
Nylon tip darts, board & authentic scoring (149377)
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RED FOX DART BOARD SET
6 brass darts & 1 board (149369)
11.43

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AQUA SLING BALLOONS 144/Bag (287995) 2.81

NERF PING PONG SET
Indoor tennis played on any size table. Won't mark. Includes net, 2 paddles & 2 balls. (297473)
14.44

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OCULAR AND ORBITAL TRAUMA FROM WATER BALLOON SLINGSHOTS - A CLINICAL, EPIDEMIOLOGICAL, EXPERIMENTAL, AND THEORETICAL STUDY

BY *John D. Bullock*, MD*, *David A. Johnson*, MD, PhD[+] (BY INVITATION), *Dilip R. Ballal*, PhD, DSc[++] (BY INVITATION), and (BY INVITATION) *Richard J. Bullock*

* From the Departments of Ophthalmology and Plastic Surgery, Wright State University School of Medicine, Dayton, Ohio, the Eye Clinic of Wichita, Wichita, Kansas[+], and the University of Dayton Research Institute, Dayton, Ohio[++]

For reprints write John D. Bullock, M.D., Professor and Chair, Department of Ophthalmology, Wright State University School of Medicine, 500 Lincoln Park Blvd., Suite 104, Dayton, Ohio 45429-3487. Presented as scientific poster #314 at the American Academy of Ophthalmology's Annual Meeting, Atlanta, Georgia, October 31 - November 1, 1995, and to the One-Hundred and thirty-second Annual Meeting of the American Ophthalmological Society, Grove Park Resort, Asheville, North Carolina, May 20, 1996.

ABSTRACT

Purpose: To report the clinical findings of seventeen patients with ocular/orbital injuries produced by launched water balloons; to determine water balloon kinetic energies in experimental and theoretical studies. **Methods:** Six case histories are presented; one case was retrieved from the medical literature; ten cases were reported to the National Injury Information Clearinghouse of the United States Consumer Product Safety Commission. The energies were determined by field trials and calculations. **Results:** Injuries included orbital contusions and hematomas, facial hypesthesia, eyelid lacerations, subconjunctival hemorrhages, corneal edema and abrasion, hyphemas, traumatic iritis, iris sphincter ruptures, iris atrophy, angle recession, iridodialyses, traumatic cataract, vitreous hemorrhages, retinal hemorrhages, macular hole formation, optic atrophy, and bony orbital wall fractures. Epidemiological analysis revealed that children and young adults, more often males, were injured, most commonly in the warm weather months (May - September). In field trials maximum water balloon velocities ranged from 38-41 meters/second (85 - 92 mph) with kinetic energies from 176 to 245 joules; by calculation, maximum velocities ranged from 42-54 meters/second (95-121 mph) with kinetic energies from 141-232 joules. In a field demonstration a 300 gram water balloon launched horizontally from a distance of 20 feet exploded a 12.0 Kg watermelon. Calculations from classical physics are presented to explain the complex biomechanical interactions between the water balloon and the eye. **Conclusion:** Launched water balloon kinetic energies are comparable to or greater than kinetic energies experienced with a variety of common objects, including rifle bullets, which are well known to cause serious

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ocular/orbital injuries. In addition, these energies are far in excess of those required to perforate a cornea (0.7 - 1.7J), rupture a globe (1 - 5.3J), or fracture the bony orbit (1.77 - 14.7J). Thus, this study demonstrates the serious and potentially vision and life threatening injuries inflicted by these "toys."

INTRODUCTION

The throwing of water balloons has been a fad for generations and usually has been regarded as a harmless prank. Popular cartoon strips have even represented this activity in a humorous light.[1] In 1988, however, a severe ocular/orbital injury as a result of a water balloon launched using an elastic slingshot was reported[2]. Since then several dozen additional injuries involving both ocular and non-ocular structures as a result of elastic slingshots have been reported to the National Injury Information Clearinghouse of the United States Consumer Product Safety Commission (NIIC-USCPSC). Herein reported are case histories of six additional patients who suffered serious ocular and/or orbital injuries after being struck by a launched water balloon. An experimental and theoretical study of the kinetic energies involved was performed.

CLINICAL STUDY

Patient 1

A 12-year-old male was struck by a water balloon launched from a sling located approximately 20 feet away. He developed marked epistaxis and swelling of the right upper and lower eyelids. An Emergency Room physician noted a hyphema in the right eye. Both eyes were patched and the patient was discharged from the Emergency Room. The following day, his visual acuities were 20/50 in the right eye and 20/20 in the left eye. The patient had a large right subconjunctival hemorrhage temporally.

A blood clot was noted from 9:00 to 11:00 in the anterior chamber angle of the right eye; in addition, a moderate amount of circulating red blood cells were seen. The left eye was not involved. He improved slowly; by 18 days after the injury, his acuity had improved to 20/20 OU. The right cornea and anterior chamber were normal. When last seen 3 months after the injury, his visual acuity was 20/20 OU with near visual acuities of J1 + OU. Intraocular pressures were 14 mmHg in the right eye and 16 mmHg in the left eye. Gonioscopy revealed a slight angle recession temporally in the right eye. The remainder of his ocular examination was within normal limits.

Patient 2

A 13-year-old male was struck by a water balloon launched from a sling at a distance of approximately 30 feet. He was noted to have marked edema and ecchymoses of the eyelids. Bilateral hyphemas were seen. A CT scan revealed blood in both maxillary sinuses without bony fractures. When seen by an ophthalmologist approximately 5 hours after the injury, visual acuities were Counting Fingers at 2 feet in the right eye and Hand Motions in the left eye. The pupils were minimally reactive and measured 4mm in the right eye and 8 mm in the left eye. Intraocular pressures were 14 mmHg on the right and 16 mmHg on the left. Ocular motility was normal. There was marked periorbital lid erythema and edema and no obvious bony defects along the orbital rims. The left cornea had a small epithelial defect. The right anterior chamber had a 1mm layered hyphema with 4+ circulating red blood cells. There was a fibrin-like clot over the pupil. The left eye had a 60% layered hyphema. Fibrin debris obscured much of the left pupillary space. Both irides appeared intact. Initially, the lenses could not be seen clearly in their entirety. There was a poor view of the right retina; there was no view of the left retina. B-scan ultrasonography showed a clear vitreous and no evidence of a retinal detachment in either eye.

Physical examination revealed no additional facial or bodily injuries. The patient was admitted to the hospital and treated for the traumatic hyphemas. He improved slowly during hospitalization. At the time of his discharge on the sixth day following the injury, his acuity had improved to 20/50 in the right eye and 20/400 in the left eye. Intraocular pressures were never elevated. The right anterior chamber showed only moderate circulating red blood cells with no hyphema. The left anterior chamber had 3+ circulating red blood cells and a large residual clot. The right iris was normal but the left iris had several small sphincter tears inferiorly. The right lens was clear. A limited view of the left lens showed slight posterior subcapsular opacification. The right fundus appeared normal. A view of the left fundus was still obscured by the blood clot. Repeat B-scan ultrasonography was normal on the left side. One month after the injury uncorrected visual acuities were 20/20-1 in the right eye and Counting Fingers in the left eye. Three months later the slit lamp examination was normal on the right side; the left eye showed iris atrophy, a mature cataract and inferior posterior synechiae. (Fig 1a.) The left eye hyphema had resolved. B-scan ultrasonography revealed no evidence of a left retinal detachment. The visual acuity measured 20/20 in the right eye and Hand Movements in the left eye. The patient then underwent a left lensectomy and an anterior vitrectomy with placement of a posterior chamber intraocular lens. The postoperative visual acuity improved to 20/30 in the left eye and has remained stable for three years of follow-up. (Fig 1b.)

Patient 3

A 9-year-old female was struck by a water balloon launched from a sling located approximately 100 feet away. On examination she had visual acuities of 20/40 in the right eye and 20/30 in the left eye. There was marked bilateral periocular edema and ecchymoses, and a 7.5mm laceration of the right upper eyelid, which did not require suture closure. The conjunctivae were chemotic bilaterally with small subconjunctival hemorrhages. The right cornea was clear and there was a 2-3mm hyphema. The vitreous in the right eye was clear. A small vitreous hemorrhage and a hyphema were noted in the left eye. Both retinas were difficult to visualize but appeared grossly normal. Orbital X-rays revealed right orbital soft-tissue emphysema; a CT scan showed a fracture of the right medial orbital wall. The patient was managed as an inpatient with resolution of the hyphemas. Two months after the injury her corrected visual acuities were 20/20 OU.

Patient 4

A 16-year-old female was hit in the right eye by a water balloon which was fired from a slingshot. She was seen in an Emergency Room and discharged. When evaluated the next day, her uncorrected visual acuity measured 20/64 in the right eye and 20/126 in the left eye. Intraocular pressures were 17 mmHg in the right eye and 12 mmHg in the left eye. She had marked ecchymoses and edema of the right upper and lower lids. (Fig 2.) She had a massive right subconjunctival hemorrhage. The slit lamp examination showed 1+ white blood cells in the right anterior chamber. There was no hyphema. The fundi were normal through dilated pupils utilizing indirect ophthalmoscopy. Topical corticosteroid eye drops were prescribed. The ecchymoses resolved; the iritis improved. Three months after the injury, the visual acuity measured 20/20 OU, the patient was asymptomatic, and the ocular examination was completely normal bilaterally.

Patient 5

A 28-year-old female was seen after being struck in the left orbital area by a water balloon launched from an elastic sling. She had severe swelling and superficial abrasions in the area of the left eye. Facial radiographs showed cloudiness of both maxillary sinuses without bony fractures. She complained of numbness of the left upper lip and cheek. She denied diplopia. The uncorrected visual acuity was 20/20 in each eye. The right eye and orbit were normal. The left eyelids were edematous and the left globe appeared to be displaced inferiorly. No palpable bony defects were noted. The inferior orbital rim was tender and there was hypesthesia in the distribution of the left infraorbital nerve. Exophthalmometry measurements were symmetrical bilaterally. There was a small left subconjunctival hemorrhage. The left cornea was clear and trace white blood cells were noted in the left anterior chamber. Motility examination revealed a slight elevation deficit of the left eye. On funduscopic examination, a few dot hemorrhages were noted in the nasal peripheral retina of the left eye. The intraocular pressures were normal. Ultrasonography demonstrated findings consistent with a diffuse left superior orbital hematoma. She was managed conservatively with resolution of her ocular and orbital abnormalities. When seen 3 months later visual acuities were 20/20 in the right eye and 20/25 in the left eye.

Patient 6

A 21-year-old female college student was hit in the face by a water balloon fired from an elastic slingshot situated on the fourth floor balcony of her dormitory. When initially seen the patient complained of bilateral ocular pain, decreased vision, and double vision. The uncorrected visual acuities measured 20/30 in the right eye and 20/300 in the left eye. (She had a preexisting anisometropia with uncorrected left myopia). A right hyphema was noted. The intraocular pressures measured 29 mmHg in the right eye and 16 mmHg in the left eye. Ecchymoses were noted in the left periorbital area along with a left subconjunctival hemorrhage and a superficial laceration of her left upper lid. The right fundus showed inferior peripheral punctate intraretinal hemorrhages. No vitreous blood or retinal holes or tears were noted. The left retina was normal. Orbital roentgenograms showed a fracture of the left orbital floor with opacification of the left maxillary sinus. A CT scan revealed a comminuted fracture of the left inferior orbital rim with soft tissues projecting through the depressed orbital floor fracture into the superior aspect of the left maxillary sinus and a comminuted and depressed fracture of the lateral wall of the left maxillary sinus. The fracture began in the inferior orbital fissure and extended medially to include portions of the medial orbital wall. (Fig 3.) Two days later the patient's best corrected visual acuity measured 20/20 in each eye. Her refraction was +0.25+0.50x140 in the right eye and -2.00+0.50x40 in the left eye. The right hyphema was clearing. The intraocular pressures measured 16 mmHg in the right eye and 18 mmHg in the left eye. Seven days after the injury the patient underwent a left blowout fracture repair with placement of a silastic sheet along the left orbital floor. When last seen 23 days after the injury the best corrected visual acuity measured 20/20 in each eye. The slit lamp examination showed complete resolution of the right hyphema. The right pupil was slightly larger than the left due to small right iris sphincter ruptures. There was 1mm of left enophthalmos and 2.5mm of left hyperophthalmos. Fundus examination was normal bilaterally; no retinal blood was noted.

EPIDEMIOLOGICAL STUDY

In Table I, patients 1-6 represent a summary of the above six patients. Patient 7 was reported previously.[2] In addition, patients 8-17 represent 10 individuals with eye and orbital injuries reported to the National Injury Information Clearinghouse of the United States Consumer Product Safety Commission between January 1, 1987 and June 30, 1995. Table II is a summary of five patients (#18-22) who sustained an ocular injury associated with a water balloon slingshot: four resulted from the elastic slingshot itself hitting the eye, and one eye was blinded by a launched potato. Table III is a summary of two patients (#23,24) who sustained eye injuries as a result of being struck by hand thrown water balloons, one of which was thrown from a moving automobile. Table IV is a summary of twelve patients (#25-36) with non-ocular injuries as a result of either a water balloon or a rock launched using an elastic slingshot. Table V is a summary of three patients (#37-39) with ocular injuries as a result of the explosions of air-filled balloons.

Graphs 1 and 2 illustrate epidemiological data of the first 17 patients, all of whom were injured by a launched water balloon. Epidemiological analysis revealed that children and young adults, more often males, were injured, most commonly in the warm weather months of May through September.

EXPERIMENTAL STUDY

A. KINETIC ENERGY DETERMINATIONS

1. VELOCITY MEASUREMENT METHOD

A study was undertaken to determine the kinetic energies which can be achieved using an elastic slingshot to launch water balloons. The kinetic energies were determined using the formula:

FORMULA 1: $KE = 1/2 \bullet M \bullet V^2$

where KE equals the kinetic energy (in joules*), M equals the mass (in kilograms), and V equals the velocity (in meters/second).

A commercially available elastic slingshot (AQUA SLING water balloon slingshot, Model #AS200, from Riva Sport Inc., P.O. Box 600404, San Diego, CA 92160), with an advertised range of 200 yards, was attached to a custom built wooden frame (Fig 4.) and was used in field trials to determine the kinetic energies of launched water balloons. A commercially available radar device (SPORTS RADAR gun, Model 3200, Sports Radar Ltd., Homosassa, FL 34448) was used to determine the velocities of the water balloons. The masses were determined using a scale. The elastic sling was elongated from its original resting length by 25 to 100 inches (63.5 - 254 cm) and the water balloons were launched horizontally. A total of 80 field trials were performed using this method. The masses of the water balloons varied between 0.10 and 0.50 kilograms, the measured velocities varied between 9-41 meters/second

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* Joule = $Kg \bullet m^2/sec^2$

(20 - 92 miles/hour), and the calculated kinetic energies varied from 7- 176 joules (Table VI).

2. RANGE MEASUREMENT METHOD

Velocity also can be determined by the formula:

FORMULA 2:

$$V = \sqrt{\frac{R \cdot g}{2 \cdot \sin a \cdot \cos a}}$$

where R equals the range (in meters), g equals the acceleration due to gravity (9.8 meters/second^2), and a equals the launch angle (in degrees). Combining formulas 1 and 2 gives the following:

FORMULA 3:

$$KE = \frac{M \cdot R \cdot g}{4 \cdot \sin a \cdot \cos a}$$

A calculation of velocities and kinetic energies based upon the experimental determination of the ranges which the launched water balloons traversed was undertaken. 15 field trials (using the above apparatus)were performed in which the launch angles varied between 20 - 47 degrees, the masses varied between 0.1 - 0.35 kilograms, and the sling elongation (total sling length minus resting length) varied from 25 - 100 inches (63.5 - 254 cm). The range was determined using a tape measure and the launch angle, a, was calculated using the following: a = arc cosine of the horizontal distance from the water balloon to the vertical upright on the custom built wooden frame, divided by the total elastic cord length. (Fig 4.) Under these experimental conditions, the ranges that the water balloons traversed were measured between 36 - 93 meters (39-102 yards)+, the calculated velocities varied between 19-38 meters/second (43 - 85 mph), and the calculated kinetic energies varied between 42 - 245 joules (Table VII).

3. COMPARATIVE ANALYSIS OF COMMERCIALLY AVAILABLE SLINGSHOTS

Formulae 2 and 3 were applied to the advertised ranges of five commercially available elastic slingshots and to the range of the custom made slingshot which caused the injury in the case reported by Holds, et al.[2] To determine the velocities and kinetic energies required to achieve the advertised (reported[2]) ranges, the following assumptions were made in performing these calculations: a) the mass of the water balloon was 0.16 kilograms, the approximate mass of a water balloon the size of a tennis ball filled with water (as recommended by the manufacturers for maximum range) and, b) the launch angle was 45 degrees, the trajectory angle which gives the maximum range. Table VIII gives the results of these calculations. Table IX is a summary of the results of methods 1-3.

B. DYNAMIC DEMONSTRATION OF WATER BALLOON IMPACT

In order to demonstrate graphically the severity of the damage caused by the impact, a water balloon was launched at a watermelon. A 12.0 Kg watermelon, having a maximum circumference of 104.5 cm, a minimum circumference of 75.5 cm, and a mean rind thickness of 12.5mm was placed vertically on a table and a 300 gram

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+ The maximum range in our experimental study did not approach the advertised range of 200 yards because maximum sling elongation was not attempted for fear of breaking the sling and causing ocular injury to the investigators. (See Tables II and VII) water balloon was launched horizontally from a distance of 20 feet, as described above. The watermelon exploded when it was hit by the water balloon traveling at a velocity of 40 meters/second (89 mph). The kinetic energy of the water balloon was 240 joules, equivalent to the effect of dropping the watermelon from a height of 2 meters onto a hard surface.

THEORETICAL STUDY

A. ENERGY TRANSFORMATION*

A water balloon slingshot, like it's distant relative, the ancient catapult, is a mechanical device which transforms potential elastic energy into kinetic energy. The potential elastic energy (EE) is derived from the elastic deformation of the extended rubber cords. The relationship between forces and displacements for linear elastic systems is described by Hooke's Law which states that the elongation, x, of a linear elastic material is proportional to the force, F, required to extend it. For a one-dimensional deformation, Hooke's law can be written $F = k \bullet x$, where k is a proportionality or "spring" constant and is related to Young's Modulus, a measure of the elastic properties of the material. Young's Modulus is the ratio: stress / strain. Work (or energy) equals the product of the magnitude of the force and the distance over which the force is exerted; therefore:

FORMULA 4: $$EE = \int_0^x k \bullet x \bullet dx$$

or, elastic energy equals the integral from elongation 0 (the resting length) to distance, x, of the force, $k \bullet x$, times the incremental distance, dx. Integration gives:

* This analysis assumes that the rubber cords are perfectly elastic and that a linear relationship exists between stress and strain.

FORMULA 5: $$EE = \frac{1}{2} \bullet k \bullet x^2$$

Therefore, the potential elastic energy is proportional to the square of the elongation of the sling. The kinetic energy imparted to the water balloon by the sling is governed by the Law of Conservation of Energy which provides that the sum of the kinetic and potential energies is a constant. Expressed mathematically, this law takes the following form:

FORMULA 6: $$\frac{1}{2} MV^2 = \frac{1}{2} . kx^2$$

When the sling is released the elastic energy, less the energy dissipation due to drag*, is thus converted into kinetic energy which hurls the water balloon on its trajectory. Ocular and orbital damage is produced in the tissues by absorbed kinetic energy.

B. IMPACT INDUCED OCULAR TRAUMA+

Damage to the eye occurs when an impacting body induces excessive strain in the involved ocular/orbital tissues. The induced strain is directly attributable to the energy imparted to the eye and orbital contents as a result of impact by a moving body and is manifested in the tissues as energy dissipated in free oscillations, heat absorption due to friction and damage to the structures of the eye and orbit. Consider the impact of a moving body (such as a water balloon) of mass, M_1, and initial velocity, V_1, colliding with a body of mass, M_2, at rest (eye, orbit, head or watermelon). Upon

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* Maximum calculated energy loss due to drag of the launched water balloons was less than 1%.

\+ A discussion of the impact dynamics of orbital trauma is beyond the scope of this manuscript.

impact (and neglecting recoil) the stationary body (M_2) absorbs a certain fraction of the initial kinetic energy of the moving body, depending upon the characteristics of the colliding bodies. The absorbed energy, T, is responsible for causing the physical damage to the tissues and the residual energy (KE - T) is lost primarily as sound, deformation of the moving body, and heat.

From impact dynamics[4] it can be shown that:

FORMULA 7:

$$\frac{T}{KE} = \left(1 - e^2\right) \bullet \left(\frac{M_2}{M_1 + M_2}\right)$$

where e is the "coefficient of restitution". This concept is best understood in the following way: if a ball is thrown against a wall with an inbound velocity V_i and rebounds outward with a rebound velocity of V_r, then the ratio V_r / V_i is defined as the coefficient of restitution, symbolized by the lower case letter e. The rebound velocity is always less than the inbound velocity because some of the initial kinetic energy is lost in friction between the ball and the wall and in internal friction between the molecules within the ball and between those within the wall. Some materials (such as a silicone rubber known as "SILLY PUTTY") may approach a perfect rebound of e=1, while other collisions may approach e=0, such as throwing an egg against a wall.[5] If e=1, the impact is said to be perfectly "elastic", there is no absorbed energy, and therefore no tissue damage. If e=0, the impact is said to be perfectly "plastic" and there is maximum absorption of energy and, therefore, maximum tissue damage.