Water park injuries

Su parkı yaralanmaları

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BACKGROUND

The purpose of this study was to identify water park injuries, particularly injuries related to waterslides.

METHODS

This prospective observational study was carried out between May 2005 and September 2006 in a university hospital emergency clinic, which has 50,000 annual visits. The study form, including patient demographics, types and mechanisms of injuries and the final diagnoses, was completed for all patients. A total of 73 patients were enrolled into the study. The mean age of the patients was 23.92±15.05 and 48 patients (65.8%) were male.

RESULTS

The mechanisms of injury were as follows: 23 patients (31.5%) were injured on waterslides, 16 (21.9%) were injured in pools and 34 (46.6%) were injured by slipping and falling on the wet surfaces. After the emergency department evaluations, 15 patients (20.5%) were diagnosed to have spinal trauma, 16 (21.9%) head trauma, 15 (20.5%) maxillofacial trauma, and 30 (41%) other injuries.

CONCLUSION

In water park injuries, while children have especially head and maxillofacial trauma, extremity and spinal injuries are more frequent in the adult group. Unless sufficient and required safety precautions are maintained during water park activities, fatal injuries may occur.

Key Words: Trauma; water park; waterslide.

AMAÇ

Su parklarına ve özellikle de su kaydıraklarına bağlı oluşan yaralanmaların özelliklerini belirlemektir.

GEREÇ VE YÖNTEM

Bu prospektif gözlemsel çalışma, yıllık hasta sayısı 50,000 olan üniversite hastanesi acil servisinde Mayıs 2005 ile Eylül 2006 tarihleri arasında yapıldı. Çalışma formuna bütün hastaların tanımlayıcı özellikleri, yaralanmanın tipi ve mekanizması ile hastaların son tanısı kayıt edildi. Çalışma süresi boyunca acil servise su parkında meydana gelen yaralanma nedeniyle 73 hasta başvurdu. Hastaların yaş ortalaması 23,92±15,05'di ve 48 hasta (%65,8) erkekti.

BULGULAR

Yaralanma mekanizması; hastaların 23'ünde (%31,5) su kaydırağında, 16'sında (%21,9) havuzda ve 34'ünde (%46,6) ıslak zeminde kayıp düşme şeklindeydi. Acil servis değerlendirmeleri sonucunda, hastaların 15'inde (%20 ,5) spinal travma, 16'sında (%21,9) kafa travması 15'inde (%20,5) maksillofasiyal travma ve 30'unda da (%41) diğer yaralanmaların olduğu saptandı.

SONUÇ

Su parkındaki yaralanmalarda çocuklarda özellikle kafa ve maksillofasiyal travma görülürken erişkinlerde ekstremite ve spinal yaralanmalar daha sık görülmektedir. Yeterli ve gerekli güvenlik önlemleri alınmayan su parkı aktiviteleri sırasında ölümcül yaralanmalar meydana gelebilir.

Anahtar Sözcükler: Travma; su parkı; su kaydırağı.

Water parks are novel fun and profitable centers in cities and their numbers have been increasing in recent years. The growth in the number of water parks has been substantial in the past 20 years, with over 1,000 water parks in North America currently and 600 more globally.[1] Water parks have become more widespread in Turkey in the past 10 years. They are potentially dangerous areas for trauma. Different types of waterslides, pools and wet surfaces in these facilities may cause a significant number of falls. Water park injuries can be categorized primarily under three headings: waterslide injuries, slips and falls on wet surfaces and swimming pool accidents. Slips and falls on the wet surfaces and injuries in swimming pool accidents have been described in detail in previous studies.[2,3]

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This is a novel topic, with relatively sparse data in the literature, most of which are case reports. However, studies on waterslide injuries are old and the presented data are insufficient.[2,4-7] Furthermore, water parks with different modern types of slides are growing daily, thus further increasing the susceptibility of the visiting patrons to trauma.

The purpose of this study was to identify water park injuries in general and to specifically define the injuries related to waterslides.

MATERIALS AND METHODS

This prospective observational study was carried out between May 2005 and September 2006 in an emergency department of a university hospital with an annual census of 50,000 patients. The study period included two summer periods in which water parks were active. All patients presenting to the emergency department with an injury occurring in a water park were included into our study. Accidents occurring in private swimming pools outside of water parks were excluded. A form developed prior to the study was completed for all patients, and included patient demographic data, the water park activity in which the injury occurred, the type and mechanism of the injury, the injured region of the body, the emergency department diagnostic and treatment interventions, and the final diagnosis.

Initial treatment was made according to Advanced Trauma Life Support guidelines, followed by physical and radiological examination to determine the severity of the injury. The mechanism of injury was established from the patient's clinical information. Radiographs, computerized tomography (CT) scans and magnetic resonance imaging (MRI) were performed depending on the patient's symptoms and clinical findings.

RESULTS

Water Park Injuries

Seventy-three patients were admitted to the emergency department with water park injuries during the study period. The mean age of the patients was 23.9±15 and 48 patients (65.8%) were male (Table 1). The mechanisms of injuries were as follows: 23 patients (31.5%) were injured on waterslides, 16 (21.9%) in the pool and 34 (46.6%) by slipping and falling on the wet surfaces. After the emergency department evaluations, 15 patients (20.5%) were diagnosed to have spinal trauma, 16 (21.9%) head trauma, 15 (20.5%) maxillofacial trauma, and 30 (41%) other injuries (Table 1).

In our study, the most frequently injured part of the body during water park activities was the extremities (26/73 patients, 35.6%). These injuries occurred mostly in the 19-35 age group (12/22 patients, 54.5%). The most common extremity injuries were sprains and strains (14 patients, 53.8%) followed by fractures (4 patients, 15.4%), lacerations (4 patients, 15.4%) and dislocations (4 patients, 15.4%).

In this study, spinal trauma was diagnosed in 15/73 patients (20.5%). Four patients (20.5%) had vertebral fractures and one of these patients had neurological deficit. However, in addition to these four patients, another patient had craniocervical dislocation accompanied by major head trauma and presented with a Glasgow Coma Scale of 7. The remaining 10 patients (66.7%) suffering from spinal trauma had no pathological finding after evaluation by physical examinations, plain radiographic views, CT and MRI. The characteristics of patients with spinal trauma are shown in Table 2.

In this study, two patients died; one with major head trauma and the other due to electrical injury. Six patients (8.2%) had surgical interventions (2 spinal trauma, 1 head trauma, 2 maxillofacial traumas, and

Table 1. Characteristic of all water park injuries

	Age			
	0-8 (n: 13)	9-18 (n: 20)	19-35 (n: 29)	36-61 (n: 11)
Gender				
Male	10	13	21	4
Female	3	7	8	7
Injury mechanism				
Waterslide	2	5	12	4
Pool	3	4	7	2
Fall (wet surface)	8	11	10	5
Injured body region				
Head	3	4	4	2
Cervical	1	1	3	1
Head-cervical	1	1	0	1
Lumbar	0	1	2	0
Thoracolumbar	0	0	1	0
Maxillofacial	4	6	3	0
Facial-cervical	0	0	2	0
Other				
Extremity sprain and strain	1	4	5	4
Extremity fracture	1	0	2	1
Extremity laceration	2	0	2	0
Shoulder dislocation	0	1	3	0
Tympanic membrane rupture	0	0	2	0
Pneumothorax	0	1	0	0
Electrical injury	0	1	0	0

Table 2. Characteristics of all patients with spinal trauma

No	Age	Gender	Injury	Neurological deficit	Treatment
1	31	Female	T12-L1 burst fracture	None	Surgery
2	43	Male	C5-6 burst fracture	None	Surgery
3	17	Male	L2-3 STI	None	Conservative
4	58	Female	L2 burst fracture	None	Conservative
5	35	Male	L STI	None	Conservative
6	4	Male	C STI	None	Conservative
7	60	Female	C STI	None	Conservative
8	17	Female	C STI	None	Conservative
9	35	Female	C STI	None	Conservative
10	44	Male	C5 dislocation	Not evaluated due to the severe head trauma	Surgery
11	22	Female	C STI	None	Conservative
12	28	Male	C STI	None	Conservative
13	22	Male	C5 burst fracture	None	Conservative
14	21	Male	C STI	None	Conservative
15	35	Male	L STI	None	Conservative

STI; Soft tissue injury; C: Cervical; T: Thoracal; L; Lumbar.

1 tube thoracostomy). The remainder of the patients in the study (65 patients, 89%) underwent conservative treatments (splinting, laceration repair and bandage, drug administration) (Table 3).

Waterslide Injuries

Most of the patients injured on waterslides were male (15/23 patients, 65.2%) and their ages ranged between 19 and 35 (12/23 patients, 52.2%) (Table 4).

In six of 23 patients (26%) with head trauma, the trauma occurred on waterslides. One of the patients in this group died (1/6 patients, 16.7%). He had neurological deficit and a positive CT scan due to the major head trauma and craniocervical junction dislocation. He struck his head on the bottom of the pool after sliding upside down. He underwent surgical intervention but died in the intensive care unit after the operation.

There were no patients with spinal trauma due to waterslide injury in the 0-16 age group; all of the six patients with spinal trauma (26%) were adults. The injured part of the spinal column was the cervical region in five patients (83.3%) and the T12-L1 vertebrae in one patient (16.7%). There were several extremity traumas due to waterslide injury in the study patients (10/23 patients, 52.2%). Six patients (50%) had sprains and strains, three patients (25%) had fractures and one patient (8.3%) had laceration (Table 4).

DISCUSSION

Injury Mechanism

Water park injuries usually occur on waterslides, in pools and on wet surfaces. The main mechanism of waterslide injuries is hitting the pool's floor or the opposite wall as a result of entering the water at an

Table 3. Emergency unit treatment of water park injuries

Emergency management	Total number of patients and frequency (n: 73)
Exitus	2
Electrical injury	1
Major head trauma	1
Surgical intervention	6
Spinal trauma	2
Maxillofacial trauma	2
Head trauma	1
Pneumothorax	1
Conservative treatment (splinting, laceration repair and bandage, drug administration)	65

Table 4. Characteristic of all waterslide injuries

	Age			
	0-8 (n: 2)	9-18 (n: 5)	19-35 (n: 12)	36-61 (n: 4)
Gender				
Male	2	4	7	2
Female	0	1	5	2
Injured body region				
Head	0	1	2	0
Cervical	0	0	1	0
Head-cervical	1	0	1	1
Lumbar	0	0	0	0
Thoracolumbar	0	0	0	1
Maxillofacial	0	1	0	0
Facial-cervical	0	0	2	0
Other	1	3	6	2
Extremity sprain and strain	0	2	2	2
Extremity fracture	1	0	2	0
Extremity laceration	0	0	1	0
Shoulder dislocation	0	0	0	0
Tympanic membrane rupture	0	0	1	0
Pneumothorax	0	1	0	0
Electrical injury	0	0	0	0

unfavorable speed and/or position. Disregard of the water park rules, sliding head first and sliding immediately after another person without an appropriate waiting period are the other possible injury mechanisms. As sketched in Figure 1, the momentum of plunging into the pool follows a linear equation according to the slide's height (y) and length (x) and in reverse equation with the friction. In waterslides in which the plunging momentum is expected to be high, the pool's depth (a) and length (b) must be arranged accordingly (Fig. 1). If the depth and length of the pool are inappropriate, a person plunging into the water with a high momentum might hit the pool's floor or the opposite wall, resulting in injury.

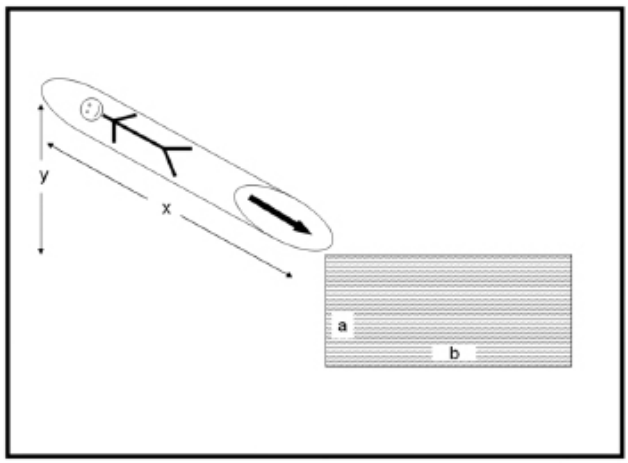

Fig. 1. Waterslide injury mechanism.
(x: Length of the slide, y: Height of the slide, a: Depth of the pool, b: Length of the pool).

As with other traumas, water park injuries are mostly observed in young male adults. The former studies describing water park injuries have pointed out that lacerations were the most frequently detected injuries, followed by sprains and strains, fractures (spine or extremity), and head trauma.[2,4,7] Similar results were obtained in our study.

In water parks, waterslides are rarely used by children aged 0-5 years; thus, in this age group, injuries usually occur in swimming pools due to slips and falls.[8] In our study, there were eight patients in the 0-8 age group (8/13 patients, 61.5%) exposed to head and maxillofacial trauma because of the falls. To eliminate these injuries, the safety precautions can be enhanced on wet surfaces. In our study, most of injured patients were in 19-35 age group (29/73 patients, 39.7%). In this age group, extremity traumas were seen at a higher frequency than head and maxillofacial traumas. The frequency of extremity trauma was 69% (14/29 patients) and of maxillofacial trauma was 31% (9/29 patients).

The most common spinal injury associated with aquatic activities reported in the literature is caused by diving into shallow waters.[9-11] Spinal injuries caused by diving affect mostly young men, and almost 50% of these cases present with complete spinal cord injury.[9,10] Paulozzi et al.[2] reported eight patients with spinal fracture due to waterslide injuries. However, in their study, there was no information about the injury mechanism. In our study, we determined that of the 23 patients (26%) with spinal trauma, trauma in six patients occurred on waterslides. Five patients in this group had cervical spine injury and one patient had thoracolumbar spine injury. Injury mechanisms were hyperflexion and striking the pool's floor. For this reason, the length and depth of the pool should be arranged considering the height and length of the slide.

Injury Patterns in Waterslide Traumas

In the literature, there are no studies describing waterslide injuries, except for Paulozzi et al.'s study[2] and two case reports, the first describing femur fracture[12] and the latter describing vaginal laceration.[13] In Leonard et al.'s study, there were 46 cases, which consisted of 10 head lacerations, nine concussions, seven lumbar compression fractures, one fractured

coccyx, two other fractures, 10 contusions, four sprains, one renal contusion, one abrasion, and one dental injury. There were similarities between the results of that study and our study according to features of the injuries. All injuries identified in our study can be seen in Table 3.

Swimming Pool-Water Park Injury Differences

The patients suffering from swimming pool accidents are younger than those injured in water parks (64%-45%).[7] Most of the swimming pool accidents occur while swimming or playing in the water. In our study, the main causes of water park pool injuries were found to be low falls (25%) and bumping into something or somebody (25%). Drowning in the water parks was found in only 2%.[7] In our study, private swimming pool accidents were not included; only the water park injuries were taken into account. Our study revealed that the most common injuries in water parks were caused by slips and falls on wet surfaces (46.6%), and there were no cases of drowning.

Water Parks and Death

In the literature, between 1972 and 1997, 15 cases of death during water park activities were reported in the United States.[14] The causes of the deaths were electrical injury in two patients and drowning in the others. In our study, one of the deaths was caused by electrical injury. The other death was caused by major head trauma and craniocervical dislocation due to the patient striking his head on the pool floor after sliding upside down. In the literature, there were no deaths reported having a similar mechanism as the patient who died in our study (44-year-old male striking his head on the pool floor because of insufficient depth of water).

Preventing Waterslide Injuries

Some of the factors causing waterslide injuries are due to human error, while others are related to conditions of the water park. Human error-based factors include sliding head first, sliding immediately after someone without a sufficient waiting period, excessive obesity, and alcohol and drug abuse. Factors based on the water parks themselves are generally related to the physical equipment. The depth and length of the pool should be arranged considering the length and height of the slide. Other measures to be taken include: taking appropriate precautions with respect to the wet surfaces, staffing a sufficient number of lifeguards especially near the pools, repairing damaged slides regularly, and establishing controls to ensure compliance with safety precautions by all patrons. Injuries can be prevented by implementing the needed personnel and the aforementioned institutional precautions. The validity of these precautions should also be checked in further studies.

One limitation to our study that should be mentioned is that most of the minor injuries occurring in the water parks are treated in the facility's own health units. Thus, it was not possible in the present study to be aware of all traumas occurring in the water parks.

In conclusion, in water park injuries, while children suffer especially head and maxillofacial trauma, extremity and spinal injuries are frequent in the adult group. Unless sufficient and required safety precautions are maintained during water park activities, fatal injuries may occur. Although extremity traumas are common in water park injuries, fatal injuries particularly due to spinal and head trauma should not be disregarded. Waterslides comprise an important injury source in water parks. Precautions to prevent the casualties in water parks may obviate the injuries.

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