Prevalence of Traumatic Injuries in Drowning and Near Drowning in Children and Adolescents

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Objective: To determine the prevalence of traumatic injuries in children involved in drowning and near-drowning accidents.

Design/Methods: Ten-year retrospective medical chart review of patients at an urban tertiary care pediatric facility. Included patients had *International Classification of Diseases, Ninth Revision, Clinical Modification* codes for fatal/nonfatal drowning or E codes for fall into water, accidental drowning, and submersion. We recorded demographics, event characteristics, diagnostics, and outcome data. We used the χ^2 or the Fisher exact test to compare patients with and without injuries.

Results: One hundred forty-three patients met inclusion criteria. Of these, 95 (66.4%) were male. Median age was 3.8 years, and 30 (23.4%) of 128 had preexisting conditions. Site of drowning was the pool (70.6%), the bathtub (19.0%), or natural water (10.4%). The prevalence of traumatic injury was 4.9% (95% confidence interval, 0%-28%). The predominant mechanism of injury was diving, and all injuries were to the cervical spine. Patients with injury were more likely to be older (mean age, 13.5 vs 5.1 years; $P<.001$) and to have a history of diving (85.7% vs 2.2%; $P<.001$). The presence of injury was not associated with sex, preexisting condition, or site of drowning ($P>.05$).

Conclusions: The prevalence of traumatic injury in drowning and near drowning is low. We identified only cervical spine injuries, and all but 1 patient had a clear history of diving. Use of specialized trauma evaluations may not be warranted for patients in drowning and near-drowning accidents without a clear history of traumatic mechanism.

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DROWNING IS a leading cause of accidental death in children. In the United States, approximately 4000 deaths, 8000 hospitalizations, and 31000 emergency department (ED) visits result per year for children aged 0 to 19 years owing to drowning or near drowning.[1] Despite aggressive prevention campaigns and advances in intensive care unit care, drowning and near drowning continue to result in substantial morbidity and mortality.[2] Epidemiological data from studies on drowning have demonstrated that most cases occur in pools.[3-5] In addition, several described risk factors are associated with drowning and near drowning. For example, the risk for a submersion injury is increased with the use of intoxicants, the presence of epilepsy, and diving.[6,7]

The role of injury as a cause and result of submersion, however, is not entirely clear. The prevalence of traumatic injuries in the setting of drowning is currently unknown. In addition, although ED care of these patients includes a thorough evaluation to rule out associated traumatic injuries, the clinical approach for evaluation of injuries is not standardized. Geographic or institutional norms may or may not involve a systematic activation of resources for trauma care (ie, trauma teams) in patients who experience drowning or near drowning (hereafter referred to as drowning/near-drowning patients). At present, advanced trauma life support guidelines do not address the issue of trauma team evaluation in these patients.[8] Furthermore, accessing these resources may be costly and difficult.

The objective of this study was to determine the prevalence of traumatic injuries in children and adolescents in drowning and near-drowning accidents. This knowledge should help to characterize the mechanisms and types of injuries associated with drowning and near drowning and would ultimately help to guide a rational and systematic approach to the management of traumatic injuries in this clinical scenario.

METHODS

We conducted a 10-year retrospective medical chart review of cases of drowning and near drowning at The Children's Hospital of Philadelphia (CHOP), Philadelphia, Pa, an urban tertiary care pediatric facility and level I pediatric trauma center that has an annual ED census of 64000 patients. CHOP also receives approximately 3100 patients each year from the surrounding community by specialized pediatric transport teams. The study period included July 1, 1989, through June 30, 1999. The study was approved by the institutional review board of CHOP.

We searched the hospital information management system for potential subjects using the following *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* or E codes[9]: 994.1 (fatal/nonfatal drowning), E883.0-9 (fall into water), and E910.0-9 (accidental drowning and submersion). We used the same codes to search the ED billing database to identify patients who were seen in the ED and subsequently discharged home. We included all patients aged 0 to 19 years, as this is the age range served by the facility. Patients who met the *ICD-9-CM* or E code criteria but who had minor trauma that occurred adjacent to a pool or a body of water and that did not involve submersion were excluded from the study.

Medical records were reviewed by a single investigator (V.H.), and the following elements were abstracted onto a structured data collection form: demographics, drowning circumstances, prehospital course, referring hospital data, ED course, interfacility transport data, and inpatient course. A 10% subset of records was also reviewed by another investigator (J.M.B.) to ensure consistency in data abstraction.

Demographic information obtained included age, race, time and date of admission to CHOP, medical history, and medications. Drowning circumstances recorded included site of drowning, activity before the event, duration of submersion, administration of cardiopulmonary resuscitation by a bystander, use of a flotation device, and use of intoxicants. Prehospital data included initial vital signs, Glasgow Coma Scale score, mode of oxygen delivery, medications used, and procedures performed. Information obtained during the ED course included initial vital signs and Glasgow Coma Scale score, use of trauma teams for evaluation, use of medications, procedures performed, consultations obtained, imaging and laboratory studies performed, diagnoses, and disposition. If patients initially presented at an outside institution, similar data were obtained from that ED medical record. Admission data included final diagnoses, presence of traumatic injuries, procedures and imaging studies performed, patient outcome, and final disposition. Laboratory and imaging study reports were reviewed independently from the ED and inpatient medical records and were taken to be the final and correct results.

The presence of a trauma team flow sheet in the medical record confirmed activation of a trauma team response. Trauma team activation consists of advanced notification of patient arrival for the following multidisciplinary individuals in addition to the ED staff: trauma surgery, pediatric critical care, radiology, and respiratory therapy. This systems response is designed to activate multiple resources that give ultimate priority to the injured patient.

Injury was defined as any injury with potential for significant morbidity and mortality and included the following: head injury, including concussion and major brain injury; cervical, thoracic, and/or lumbar spine fractures; spinal cord injury; thoracic organ injury; intra-abdominal organ injury; pelvic fractures; long-bone fractures; and major vessel injury.

Descriptive statistics are presented as mean±SD. Frequency data are presented with 95% confidence intervals (CIs).

Table 1. Patient and Event Characteristics

Variable	Data*
Demographics	
Total No. of patients	143
Age	
Mean, y	5.6
Median, y	3.8
Range	1.2 mo-18.7 y
Male	95 (66.4)
Event characteristics	
Drowning site	
Pool	101 (70.6)
Bathtub	27 (19.0)
Natural water	15 (10.5)
Drowning circumstances	
Inability to swim	44 (30.7)
Bathtub/unattended	20 (14.0)
Diving	10 (7.0)
Medical condition	7 (4.9)
Intentional/assault	6 (4.2)
Equipment failure	3 (2.1)
Fall	2 (1.4)
Unknown	51 (35.7)
Submersion time†	
Median, min	3.00
Range	<1 min-1 h
≤2 min	38 (40.0)
>2 min	57 (60.0)
Bystander CPR‡	98 (70.5)
Flotation device§	7 (4.9)
Intoxicant use‖	0
Glasgow Coma Scale score¶	
15	65 (50.8)
13-14	11 (8.6)
9-12	4 (3.1)
4-8	8 (6.3)
3	40 (31.2)

Abbreviation: CPR indicates cardiopulmonary resuscitation.
*Unless otherwise indicated, data are expressed as number (percentage).
†Data include 95 patients.
‡Data include 139 patients.
§Data include 142 patients.
‖Only 6 patients underwent toxicologic screening.
¶Data include 128 patients and reflect the best score at the referring or the study institution.

We used the χ^2 or the Fisher exact test (2×2 tables) to compare patients with and without injuries. Statistical significance was defined as $P<.05$. All analyses were performed using SAS statistical software (Version 8.0; SAS Institute Inc, Cary, NC).

RESULTS

One hundred fifty-five patients had appropriate *ICD-9-CM* or E codes. Of these, 152 medical records were available for review. Nine patients were excluded because they had minor trauma that occurred adjacent to a pool and did not involve submersion, leaving 143 patients in the final analysis. Demographic information, event characteristics, and ED presentation characteristics of the study sample are described in **Table 1**.

Medical history was documented in 128 of 143 patients. Of these, 30 (23.4%) were identified as having preexisting conditions. Three of these had a history of congenital heart disease; 6, seizure disorder; 5, cerebral palsy/

Table 2. Characteristics of Injuries*

Age, y/Sex	Injury Type	Injury Mechanism
12.8/M	C6-C7 subluxation	Diving
9.8/F	C4 fracture	Diving
12.9/M	C6-C7 fracture	Assault
14.7/M	C6 fracture	Diving
15.3/M	C4-C6 fracture	Diving
14.2/F	C6 fracture	Diving
14.9/M	C4-C5 cord contusion	Diving

*Injuries all occurred at a pool.

mental retardation; 6, developmental delay; and 10, other medical conditions.

We found that 7 patients (4.9% [95% CI, 0%-28%]) had injuries. **Table 2** shows all 7 patients with their ages, sex, sites of drowning, injury types, and injury mechanisms. Most patients were male. All injuries occurred in a swimming pool. Cervical spine injury was the only injury sustained and was caused by diving for all but 1 patient. None of these patients died.

When we compared the 7 patients with injury with those without injury, patients with injury were more likely to be older (mean ages, 13.5 vs 5.1 years; $P<.001$) and to have a history of diving (85.7% vs 2.2%; $P<.001$). Sex, preexisting conditions, and site of drowning were not different for patients with vs those without injury ($P>.05$).

Ninety-five of 143 patients underwent initial evaluation at outside hospitals. Of all the study patients, 7 (4.9%) were discharged to home, and 3 (2.1%) died. Of the 133 patients (93.0%) admitted to the hospital, 99 (69.2%) were discharged to home, 11 (7.7%) were discharged to a rehabilitation facility, and 23 (16.1%) died due to anoxic brain injury secondary to submersion.

COMMENT

The prevalence of traumatic injury in our drowning/near-drowning population was 4.9%. Cervical spine injury was the only injury identified, and all but 1 injured patient had a clear history of diving.

To our knowledge, this is the first case series to examine the prevalence of injury among submersion victims in the pediatric age group. Providers who care for drowning/near-drowning patients have been recommended to be aware of possible trauma, especially cervical spine injuries.[10-12] However, unlike the well-known risk factors for submersion injury (ie, intoxicant use and seizure disorder), the association between injury and drowning has been infrequently described in the literature.[6,7]

All of the injuries identified in the study were sustained in a swimming pool, and in 6 of 7 patients, the injury was secondary to diving. A clear association has been described between diving and cervical spine injuries.[13,14] In a recent retrospective study of diving injuries, 71% of patients sustained a major cervical spine injury, compared with our study, in which 6 (60%) of 10 patients with a history of diving had cervical spine inju-

ries.[13] The injury most often occurs as a result of striking the head on the bottom of the pool after miscalculation of the water's depth. Injuries to the C5 through C6 levels are the most common.[15]

Recently, Watson et al[16] specifically looked at cervical spine injuries among submersion victims with the hypothesis that a cervical spine injury is unlikely in those who do not sustain high-impact injuries such as those caused by water sports and diving. They found that patients in 11 (0.5%) of 2244 submersions had cervical spine injuries as a result of diving, a motor vehicle crash, or a fall from height, all considered high-risk submersions. Patients without a history of high-impact submersion or without physical signs of severe injury did not have cervical spine injuries. The prevalence of injury in their study was much lower than in our study because of differences in the study populations. Our population was restricted to a tertiary care pediatric center, whereas their study included patients of all age groups and patients who died at the scene and were taken to the medical examiner.

Few other studies describe injuries in drowning patients. Lavelle et al[17] studied pediatric bathtub near drownings and determined that 12 (63%) of 19 patients had historical and/or physical findings suggestive of abuse or neglect. The physical injuries described included bruising (n=2), fractures (n=2), and retinal hemorrhages (n=1) and most likely occurred before the submersion event. Other studies mention isolated case reports of head injury that occurred before drowning or as a result of resuscitation.[18,19]

This study demonstrates the importance of obtaining a clear history when submersion victims undergo evaluation. Those patients with a history of a traumatic mechanism such as diving should undergo evaluation by specialized trauma teams. However, the need for an elaborate use of resources for every submersion victim may not be warranted.

Several limitations to our findings should be considered. First, for a retrospective study, we rely on accurate abstraction of data from charts. Documentation omissions may have led to incomplete data.

We did not control for the type of evaluations that patients received, and injuries may have been overlooked. In addition, we did not obtain follow-up data on discharged patients. However, as most patients were admitted, it is unlikely that we missed injuries resulting in significant morbidity. Injuries also may have been missed in patients undergoing active resuscitation on presentation to the ED who died shortly thereafter. We may have missed patients because of code selection and, because we did not search medical examiner records, we may have missed patients who died at the scene.

CONCLUSIONS

This study highlights the importance of obtaining a detailed history pertaining to drowning circumstances, as most cervical spine injuries resulted from diving. Determination of whether a traumatic mechanism was involved is crucial and would help guide a more rational approach to the use of specialized trauma resources in

This is the first case series, to our knowledge, that examines the role of traumatic injury in the setting of pediatric drowning and near drowning. At present, we do not know the prevalence of injury in this population. Furthermore, although ED care of these patients includes a thorough evaluation to rule out associated traumatic injuries, the clinical approach for evaluation of injuries is not standardized and may or may not involve a systematic activation of trauma care resources.

In our study, the prevalence of injury was found to be low. All patients with injury had cervical spine injuries, with a diving mechanism in most. This study highlights the importance of obtaining a detailed history pertaining to the circumstances of drowning. Determination of whether a traumatic mechanism is involved is crucial and would help guide a rational approach in evaluating submersion injuries. Based on this case series, the use of specialized trauma teams appears not to be necessary for most patients with submersion injury.

this scenario. Based on this case series, it would appear that use of a specialized trauma team is not necessary for most patients with submersion injury. We recommend that hospitals develop individual policies with regard to use of specialized trauma resources in the evaluation of drowning and near drowning in children and adolescents after careful review of their unique patient populations.

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