Freshwater Submersion Injuries in Children: A Retrospective Review of Seventy-Five Hospitalized Patients

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ABSTRACT. *Objective.* **To determine whether or not selected victims of submersion accidents can be safely managed as outpatients.**

Design. **Retrospective chart review.**

Setting. **Children's Medical Center of Dallas.**

Patients. **One hundred forty-eight charts reviewed, comprising all hospital admissions after submersion accidents from April 1987 to April 1994.**

Results. **Of the 148 patient charts that were reviewed, 73 patients were excluded from the study for the following criteria: endotracheal intubation before initial medical evaluation; transfer form an inpatient unit of another medical facility; history of preexisting neurologic, neurodevelopmental, and/or pulmonary disease. Of the 75 evaluable patients, 3 were directly admitted to the inpatient service with no documented initial medical evaluation reported in the medical record. Of the remaining 72 patients, 62 (86%) were symptomatic at the time of the initial medical evaluation in the emergency department; 10 patients (14%) were asymptomatic. Seventy percent of the initially asymptomatic patients and 57% of patients who were symptomatic at the time of initial medical evaluation were asymptomatic by 8 hours after the submersion event. By 18 hours postsubmersion, all patients who were initially asymptomatic and 72% of initially symptomatic patients were normal. Thirty-five percent and 80% of patients who had abnormal initial physical examinations and abnormal chest x-rays had a normal physical examination by 8 hours and 18 hours, respectively, and all remained normal.**

Conclusions. **Routine hospital admission of all children who have had immersion accidents is unnecessary.** *Pediatrics* **1996;98:368–371;** ***submersion injuries, drowning, near-drowning, freshwater injuries, water accidents.***

ABBREVIATION. ED, emergency department.

Submersion injuries are a cause of substantial morbidity and mortality in children. In the United States there are approximately 6500 drowning deaths per year.[1] Another 3000 children who are less than 5 years of age are evaluated in emergency departments (EDs) for near-drowning and the majority are admitted to the hospital for observation and treatment.[2–4]

Submersion injuries in children occur in a bimodal distribution with the first peak occurring in patients 6 months to 4 years of age and a second peak at 18 to 24 years of age.[5] The site of submersion injuries is age-dependent. In infants less than 1 year of age the most frequent site of drowning is the bathtub and as many as 67% of reported cases may be secondary to abuse or neglect;[6] by contrast, the majority of children between 1 and 4 years of age drown in swimming pools. In these latter age groups, it has been estimated that between 5% to 19% of the injuries are related to child abuse and neglect.[1,5] In older children and adolescents, males predominate over females and alcohol and illicit drug use, seizures, daredevil behavior, trauma, and hyperventilation are frequent antecedents.[7,8] In all age groups the submersion episode is frequently related to a lapse in adult supervision.[1,9,10]

In reviews of the subject of drowning and near-drowning events with particular emphasis on management and the predictors for survival and outcome, virtually all authors recommend that patients who have sustained a submersion episode, including those with a normal physical examination at the time of initial medical evaluation, should be hospitalized because they are at risk for an abrupt clinical deterioration.[1,11–13] Olshaker[5] recommended a minimum 24-hour admission for all patients, including asymptomatic patients who may have had a significant submersion episode. Similarly, Fiser[1] recommended routine hospitalization based on her experience that even patients who appear mildly affected on initial presentation may develop cerebral edema and deteriorate during the next few days.

As public awareness increases through education in cardiopulmonary resuscitation techniques, more submersion victims received resuscitation at the site of submersion; this results in improved survival rates and more visits to EDs. Concomitantly, the emergence of managed care has encouraged physicians to review the necessity for multiple laboratory tests and hospital admissions. Critical pathways are being formulated and implemented in an effort to standardize medical treatment for selected disease processes to reduce costs and unnecessary hospital admissions.

We have observed that near-drowning patients with a normal physical examination on admission to the hospital from the ED often remain normal and do not require extended hospitalization. These observations prompted us to conduct a retrospective study to determine whether or not selected victims of sub-

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mersion episodes could be safely managed as outpatients.

METHODS

Subjects

The clinical records of 148 patients hospitalized from April 1987 through April 1994 at Children's Medical Center of Dallas (age criteria; 1 day to 18 years) with a primary diagnosis of drowning, near-drowning, or submersion injury were included in this review. The only criterion for a diagnosis was being evaluated in an ED with history of submersion in fresh water and being admitted to a hospital inpatient unit. Drowning was defined as a submersion episode that resulted in asphyxia and death within 24 hours of the episode and near-drowning was defined as a submersion episode that resulted in the victim seeking medical attention, but not severe enough to result in death within 24 hours.[1]

Seventy-three patients were excluded from the study. Exclusion criteria were patients who underwent endotracheal intubation before inpatient admission, patients who were transferred from another hospital inpatient unit, and those with a history of preexisting neurological, neurodevelopmental, and/pulmonary disease. A small number of asymptomatic patients who were evaluated in our ED with an equivocal history of a submersion episode and were discharged home were not included in this review.

Statistical Evaluation

The data were analyzed in a univariate fashion through the use of χ^2 statistics.[14] A multiple logistic regression model was used to examine the results in a multivariate manner.[15] A backwards elimination procedure was used to reduce the number of variables.

RESULTS

The age range of the patients was 6 months to 13.3 years (mean age, 2.5 years). The male to female ratio was 1.4:1 (Table 1). Eighty-five percent of the victims had a submersion episode in a swimming pool, 8% in a bathtub, 3% in a hot tub, 3% in a pond, and 1% in a toilet.

Sixty-two (86%) of the 72 evaluable patients who had a physical examination recorded at the time of arrival in the ED were symptomatic (respiratory rate greater than 30, crackles, wheezes, or coarse breath sounds on auscultation; a need for supplemental oxygen based on the judgment of the attending physician; unresponsive, stunned, sleepy, limp, crying, or combative); 10 (14%) had a normal physical examination. The findings from the initial physical examination were not recorded in 3 patients. When the histories obtained from patients with a normal initial physical examination were compared with those obtained from patients with abnormal initial physical examinations, there were no significant differences between the two groups with regard to the duration of submersion ($P = .8$), apnea ($P = .4$), pulselessness ($P = .4$), level of consciousness ($P = .5$), or the type of resuscitation used at the site ($P = .2$). Similarly, with the exception of the duration of submersion there were also no significant differences between the histories obtained from patients with normal and abnormal hospital admission physical examinations. Patients who had an abnormal examination at the time of admission to the hospital had a significantly longer duration of submersion ($P = .04$) than did inpatients who were asymptomatic (Table 2).

Forty percent of patients whose physical examination was initially normal in the ED developed an abnormal examination during the period of hospitalization. Onset of symptoms occurred within 4.5 hours of the submersion in all but one of the patients; in the remaining patient, symptoms first appeared at 7 hours postsubmersion and resolved by 8 hours posthospital admission. Ninety percent of patients with a normal initial examination and 57% of all patients who were symptomatic at the time of initial medical evaluation were asymptomatic by 8 hours after the submersion event. By 18 hours postsubmersion, all patients who were initially asymptomatic and 72% of initially symptomatic patients were normal.

Twenty-eight patients (37%) developed fever (>38°C) after the submersion event. There was no statistically significant difference in the prevalence of fever between patients with normal and abnormal initial physical examinations ($P = .7$); however, patients who had an abnormal examination at the time of admission to the inpatient service had a larger prevalence of fever (55%; $P = .0003$) than those whose examination was normal at the time of hospital admission (13%). The median time of onset of fever was 5 hours postsubmersion (range, 2.5 to 50 hours); 84% of patients developed fever within 12 hours of the submersion episode. The duration of fever was brief in most patients; only 4 (16%) patients had temperatures >38°C for more than 8 hours. Two of the latter patients had an otherwise normal physical examination and the fever resolved spontaneously. The other 2 patients had roengtenographic evidence of pneumonia for which antibiotics were administered. Overall, fever resolved spontaneously in 80% of patients; 5 patients received antimicrobials for treatment of acute otitis media (1) or pneumonia (4).

Chest roentgenograms were abnormal in 28 (46%) of 61 children who had studies performed at the time of initial medical evaluation or admission to the hos-

TABLE 1. Demographics of 148 Children Who Experienced Submersion Episodes

	Included	Excluded*
Number of patients	75	73
Male:female	1.4:1	1.6:1
Mean age	2 y, 5 mo	3 y, 1 mo
Median age	2 y, 11 mo	2 y, 5 mo
Age range	6 mo–13.5 y	3 mo–15.5 y
Endotracheal intubation before initial evaluation	0	58 (80)
Transferred from other medical facility	0	9 (12)
History of prior neurologic, neurodevelopmental, or pulmonary disease	0	6 (8)

* The numbers inside the parentheses indicate the percentage of patients.

TABLE 2. Correlation Between History and Physical Findings*

	Initial Emergency Room Examination						Examination at Time of Hospital Admission					
	Normal			Abnormal			Normal			Abnormal		
	Yes	No	Unknown	Yes	No	Unknown	Yes	No	Unknown	Yes	No	Unknown
Scene events and condition												
Duration of submersion ≤2 minutes	5 (50)	3 (30)	2 (20)	24 (39)	23 (37)	15 (24)	14 (45)	8 (26)	9 (29)	16 (36)	18 (41)	10 (23)
Apnea	6 (60)	1 (10)	3 (30)	36 (58)	15 (24)	11 (18)	13 (42)	11 (35)	7 (23)	30 (18)	6 (14)	8 (18)
Absence of pulse	4 (40)	...	6 (60)	33 (53)	4 (7)	25 (40)	18 (58)	2 (7)	11 (35)	21 (48)	2 (4)	21 (48)
Loss of consciousness	7 (70)	3 (30)	...	34 (55)	28 (45)	...	18 (58)	13 (42)	...	25 (57)	19 (43)	...
Type of resuscitation	CPR	MTM	Unknown	CPR	MTM	Unknown	CPR	MTM	Unknown	CPR	MTM	Unknown
	4 (40)	5 (50)	1 (10)	11 (18)	28 (45)	23 (37)	6 (19)	11 (35)	14 (45)	9 (20)	23 (52)	12 (27)

Abbreviations: CPR, cardiopulmonary resuscitation; MTM, mouth-to-mouth resuscitation.
* The numbers inside the parentheses indicate the percentage of patients.

pital. Abnormal findings ranged from minimal fine perihilar infiltrates to basilar infiltrates or atelectasis. Lobar consolidation was rarely present (4%). Seven of 10 patients with a normal initial physical examination had a normal chest x-ray and this procedure was not performed on the other 3 patients. Chest x-rays were normal in 26 (48%) of the symptomatic children who had them performed at the time of the initial medical evaluation. Thirty-five percent and 80% of patients who had abnormal initial examinations and abnormal chest x-rays had a normal physical examination by 8 hours and 18 hours, respectively, and all remained normal.

We did not identify any documented hospital admission based on social concerns; therefore, the issue of concern for the safety of the child due to suspected neglect or abuse was not addressed in this review. Similarly, no patients developed postimmersion syndrome during the period of hospitalization.

DISCUSSION

Despite the fact that drowning is the second leading cause of accidental death in children and submersion injuries account for substantial morbidity and mortality,[16] there have been no objective data evaluating the criteria for hospital admission for submersion victims. Before the 1970s research on submersion injuries focused on the effects of fresh and salt water on electrolytes and volume changes. The recommendations for management of near-drowning victims were based on animal studies and extrapolated to humans.

During the 1970s investigators refocused in an effort to study the effects of drowning and near-drowning on humans. During that period, public awareness of cardiopulmonary resuscitation resulted in an increase in the number of victims being resuscitated at the site of submersion and increased survival. In 1976 Modell et al[11] conducted a retrospective study of 91 near-drowning victims and made several important observations based on the data. They found that cardiopulmonary resuscitation was effective if given at the site of submersion and that large shifts in electrolytes that occurred in animals subjected to submersion were not seen in human survivors. By the late 1970s and 1980s the focus shifted toward identifying indicators that predict long-term outcome in near-drowning survivors and on better methods to educate the general public to prevent submersion events. During the 1990s, the foci of research and reviews have been to identify predictable markers for long-term outcome and devise better management regimens. The standard of care for near-drowning victims in the 1990s, even those who appear clinically well at the time of initial medical evaluation, is mandatory admission to the hospital because the potential for delayed deterioration and the development of life-threatening complications is a matter of concern.[1,5]

The results of this retrospective study indicate that there is no correlation between the history of a submersion episode, which has routinely been used to determine the need for hospital admission, and the subsequent clinical course. Although recent recommendations state that victims of a significant submersion should be hospitalized,[1,5,13,17] our data indicate that routine hospital admission is not necessary for all children who have had a submersion episode. Although 69 of 75 patients (92%), including 4 of 10 children who were asymptomatic at the time of their initial medical evaluation, developed symptoms at some point after their immersion, 63% and 77% were asymptomatic at 12 and 18 hours, respectively, and none developed late complications. Ninety-eight percent of patients who developed symptoms did so during the first 4.5 hours after their immersion; 1 patient did not develop symptoms until 7 hours postsubmersion.

A potential source of bias in this study was the omission of a subgroup of submersion subjects who were seen in the ED and sent home. Based on the current standard of care for admission of all victims of near-drowning events who may be asymptomatic with a significant history of submersion, we do not feel this omission biases our recommendations.

With the exception of a normal chest x-ray in an asymptomatic patient, we found that chest x-rays are not reliable predictors of the clinical course and an abnormal chest x-ray alone should not be used as an indication for hospital admission. Eighty percent of initially symptomatic children with abnormal chest x-rays were well at 18 hours postsubmersion event.

Fever after a submersion episode is common, the duration of temperature elevation is generally short. Fever does not require treatment with antimicrobials

in the first 48 hours as previously recommended by Olshaker[5] and Modell.[11]

Based on the findings of this review, we make the following recommendations for children who have experienced a freshwater submersion episode for which medical attention was deemed necessary: Ill, symptomatic children should be initially stabilized in the ED and promptly admitted to an intensive care unit or hospital inpatient unit. All other children should receive a full medical evaluation and be observed in the ED or observation unit for a period of 6 to 8 hours. Asymptomatic children who do not develop symptoms during the period of observation do not require hospitalization and can be discharged home with a follow-up telephone call. A chest x-ray is not needed in these patients. Children who are mildly symptomatic but stable at the initial evaluation should be observed for a 6 to 8 hour period. If there is deterioration in their status during the period of observation or if they continue to be symptomatic after 8 hours of observation, they should be promptly admitted to the appropriate inpatient facility. An abnormal x-ray should not be considered as a sole criterion for admission in these patients. Patients who were initially symptomatic but who have returned to normal during the period of observation can be discharged home with follow-up in 24 hours.

The aforementioned algorithm would have identified all normal patients and all patients who were initially normal but who developed an abnormal physical examination. These criteria for hospital admission would have eliminated 29% of near-drowning admissions analyzed in this study.

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