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ORIGINAL ARTICLE

Predictors for hospital admission of asymptomatic to moderately symptomatic children after drowning

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Abstract

Drowning is a leading cause of injury-related death worldwide, but there are limited data on the management and disposition of asymptomatic and mildly symptomatic adults and children following a drowning event. Some authors have recommended admission for all drowning victims due to the possibility of respiratory and clinical deterioration in a seemingly well patient. In order to identify predictors for admission and to establish a unified approach for management, we retrospectively collected all children ≤ 16 years old presented following a drowning event to the pediatric ED over a period of 12 years. The children were divided into two groups, those who were discharged home from the ED and those who were admitted. Seventy-one surviving and non-intubated children were asymptomatic to moderately symptomatic, and they comprised the study group. Crepitations on lung auscultation, oxygen desaturation, and respiratory distress were significantly higher in the admitted group ($n = 26$) compared with the discharged group ($n = 45$) ($P < 0.05$). Respiratory distress and lung crepitations were independent predictors for admission. Eventually, 30% of the hospitalized patients required oxygen therapy, but there were no cases that deteriorated and required invasive ventilation. No readmissions occurred in the group of children who were discharged from the ED.

Conclusion: Children who after six hours show no respiratory distress and have normal oxygen saturation and normal auscultation can be safely discharged home. Respiratory distress and lung crepitations should both warrant the physician to consider admission of asymptomatic to moderately symptomatic children following a drowning event. An algorithm to assist patient management is proposed.

What is Known:
•*There are few data in the literature regarding the management and disposition of asymptomatic to moderately symptomatic children after drowning.*
What is New:
•*We found that respiratory distress and lung crepitations are independent predictors for admission. An algorithm to assist patient management is proposed.*

Keywords Children · Non-fatal drowning event · Respiratory distress · Lung crepitations · Disposition

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Introduction

Drowning is a leading cause of injury-related death worldwide among boys 1 to 14 years of age, with a death rate of 3 per 100,000 events in the USA [1, 10]. According to the new definition adopted by the WHO in 2002, "Drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid" [16, 17]. Fewer than 6% of all rescued adults need medical attention [15], and the majority of those brought to the hospital are discharged home from the emergency department (ED) [9, 15]. In contrast, Cantu et al. reported a 65% hospital admission rate of all rescued children in a tertiary care children's hospital in the USA [3]. Moreover, according to a CDC report, more than 50% of children treated in US EDs for drowning in 2001–2002 required hospitalization [5]. After drowning, some authors recommended routine admission due to the possibility of respiratory and clinical deterioration even in a seemingly well patient, but recent studies demonstrated that in asymptomatic and mildly symptomatic patients after a drowning event, there is no correlation between the history of submersion episode and the subsequent clinical course [4, 7, 11, 12, 18].

There are limited data on the management and disposition of asymptomatic and mildly symptomatic adults and children after drowning. This may be due to the wide variation of clinical presentations of these individuals: those who are asymptomatic will require no more than a physical examination to rule out the need for intervention, while the symptomatic ones may need laboratory and radiologic evaluations as well as interventions and admission to intensive care units or hospital wards [3, 8, 14, 16].

There are a few algorithms in the literature regarding managing adult and pediatric drowning. For example, Semple-Hess and Campwala proposed an algorithm for managing pediatric drowning based on the Glasgow Coma Score, on the evidence of respiratory distress, and on the presence of hypothermia [14]. Moreover, Szpilman et al.'s classification system, which was designed to stratify the risk of adults' and children's drowning–related sequelae and to guide interventions, included in their grading system the patient's level of consciousness, the findings on auscultation, and the hemodynamic status, while respiratory distress and oxygen saturation were not taken into account [15, 16].

The aim of the current study was to investigate the clinical characteristics and management of asymptomatic to moderately symptomatic children after drowning in order to identify predictors for hospital admission after a 6-h observation period and to establish a unified approach for the management of children after drowning.

Methods

Study design and setting

This study was a retrospective medical record review conducted in an urban tertiary care center in Israel, whose entire western border is the Mediterranean Sea. We reviewed the medical records of all of patients younger than 16 years of age who presented to the pediatric ED between 1 January 2007 and 31 December 2018 after drowning. The subjects were identified using International Classification of Diseases, Ninth Revision (ICD-9) code 994.1.

The medical records were retrieved by two investigators (N.C. and T.C.) who extracted the following data from the reports of the medical staff, the family, and the paramedics: demographics, details of the event (cause, place, the water content, month of year, estimated submersion time, prehospital treatment), clinical findings from the physical examination, vital signs, treatment (including details of cardiopulmonary resuscitation (CPR) if provided), results of blood tests and radiographic investigations, and disposition. CPR was defined as a performance of ventilatory assistance and/or chest compression. The provision of ventilatory support was also documented, and it included oxygen therapy, heated humidified high-flow nasal cannula (HHHFNC), and intubation. The patients were divided into two subgroups according to their disposition: one group was comprised of children who were discharged home after at least a 6-h stay in the ED and the other was comprised of children who were admitted to either the pediatric intensive care unit (PICU) or a pediatric ward according to the clinical judgment of the attending ED physician.

Statistical analysis

Data entry and analysis were performed using SPSS Statistics, version 24 (SPSS Inc., Chicago, Illinois). Normality of the data was assessed by the Kolmogorov–Smirnov test. The Student *t* test was used for normally distributed data, and the Kruskal–Wallis test was used for non-normally distributed data. Pearson's or Spearman's test was used for correlational analyses. Results are expressed as mean ± SD and median (range) when appropriate. A binary logistic regression analysis of patients who were discharged from the ED vs. those who were admitted, and patients with respiratory distress vs. those with normal breathing in the initial evaluation in the ED or during the 6-h observation, as the dependent variable was performed with variables with a P value < 0.50 in the univariate analysis. A P value of < 0.05 was considered statistically significant in the regression analysis.

The study was approved by the local institutional ethics committee (Helsinki).

Results

The records of 80 children who underwent drowning during the study period were evaluated. Of them, the 73 children arrived to the ED awake and non-intubated with and without symptoms of respiratory distress. The data of one patient with a C5 fracture and one patient whose drowning event was attributed to a suicidal attempt were excluded. The median age of the final cohort was 5.0 (IQR 2.5–5.0) and 41 were males (51%). We divided these 71 asymptomatic to moderately symptomatic patients into two subgroups: 45 children (63%) who were discharged home from the ED and 26 patients (37%) who were admitted to either the PICU or a pediatric ward.

The demographic and clinical features of the study group according to their disposition are presented in Table 1. Crepitations, GCS < 15, desaturation, respiratory distress, and respiratory acidosis, either in the initial ED examination or during the 6-h observation period, were significantly higher in the admitted group compared with the discharged group. Only bilateral crepitations and respiratory distress remained significant for $P < 0.05$ in the stepwise multivariable model (Table 2). Importantly, an estimated submersion time > 1 min, the performance of CPR, and the presence of hypothermia were not significantly different between the two groups.

We then compared the patients who have normal breathing and were free of any retractions or tachypnea with the patients in respiratory distress upon arrival to the ED. The latter patients had significantly more crepitation, GCS < 15, desaturations, respiratory acidosis, and antibiotic treatment ($P < 0.05$), and they were more frequently admitted to the hospital (87% vs. 12.5% admission rate, $P < 0.001$) (Table 3). The estimated submersion time was longer than 1 min in almost one-half of the patients with respiratory distress. The rate of CPR performance was similar for the two groups.

Finally, of the 26 patients who were admitted (either to the ward or to PICU), 8 patients (30.7%) needed oxygen therapy during their hospitalization period and 1 patient (3.8%) needed heated humidified high-flow nasal cannula (HHHFNC). None of the patients deteriorated to invasive ventilation.

Discussion

There are few data in the literature regarding the management and disposition of asymptomatic to moderately symptomatic children after drowning [14]. Some authors have recommended admission for all drowning victims due to the possibility of respiratory and clinical deterioration in a seemingly well patient [7, 12, 18]. However, more recent studies have

Table 1 Bivariate comparison of asymptomatic to moderately symptomatic patients who were discharged home and those who were admitted to the hospital after drowning

Variable	Discharged ($N = 45$)	Admitted ($N = 26$)	P value
Age in years, median (IQR)	4.9 (2.5–8.0)	6.5 (2.0–9.0)	0.996
Male gender	24 (53.3)	13 (50)	0.78
Water type			
Fresh water	28 (62.2)	13 (50)	0.33
Salt water	17 (37.8)	13 (43.3)	
Estimated submersion time > 1 min	11 (24.4)	11 (42.3)	0.117
CPR performed	22 (48.9)	12 (46.2)	0.824
GCS			
15	44 (97.8)	21 (80.8)	0.02
11–14	1 (16.7)	5 (83.3)	
Respiratory distress at the initial ED evaluation/after 6-h observation	3 (6.7)	20 (76.9)	< 0.001
Crepitations at the initial ED evaluation/after 6-h observation			
None	35 (79.5)	6 (23.1)	< 0.001
Unilateral	4 (9.1)	8 (30.8)	
Bilateral	5 (11.4)	12 (46.2)	
Desaturation < 92% at the scene/initial ED evaluation	15 (34.1)	21 (80.8)	< 0.001
Hypothermia < 35 °C	1 (2.2)	1 (4)	0.657
Respiratory acidosis: pH < 7.35	15 (33.3)	18 (69.2)	0.004
Antibiotic treatment	1 (9.1)	8 (32)	0.22

Data are presented as number (%) unless indicated otherwise

IQR interquartile range, *CPR* cardiopulmonary resuscitation, *GCS* Glasgow Coma Scale

Table 2 Multivariable analysis of predictors for admission

Variable	Odds of admission—adjusted OR (95% CI)	*P* value	(95% CI)
Respiratory distress	32.7	< 0.001	6.4–164.6
Crepitations			
Unilateral	6.8	0.053	0.9–48.5
Bilateral	9.2	0.013	1.5–53.7

OR odds ratio, *CI* confidence interval

demonstrated no delayed deterioration in children with normal room air oxygen saturation at 6 h post-submersion and normal physical examinations for 8 h, concluding that routine hospital admission of all children who have had immersion accidents is unnecessary [4, 11, 14].

In our current cohort, the majority of the asymptomatic to moderately symptomatic patients were discharged home from the ED. Auscultation findings positive for crepitations and respiratory distress were independent predictors for admission to hospital.

Although 36% of children did show signs of mild deterioration during the 6 h of observation, presenting as respiratory distress (23 patients, 32.3%), desaturation (36 patients,50%), and eventually the need for supplemental oxygen (8 patients, 11.2%) or non-invasive ventilatory support (1 patient, 1.4%), the majority (63.3%) were asymptomatic or rapidly improved. The children that were asymptomatic after 6 h were discharged home. The fact that no readmissions occurred supports that this was a safe practice.

Among the admitted patients, about one-third needed continued oxygen support during the first hours of stay in the hospital. Regardless of the disposition, the children in respiratory distress had more respiratory acidosis, crepitations, and desaturations, but there was no case of deterioration that required invasive ventilation. In children who are symptomatic after 6 h of observation, further deterioration of the respiratory symptoms can occur, in rare cases even to those requiring invasive ventilation, and therefore, admission is warranted.

Although in our study, probably due to the relatively small study population, no child developed severe acute respiratory distress syndrome (ARDS) with the need for invasive ventilation, it is important to identify children in danger of severe ARDS rapidly and arrange for admission to a PICU. Signs to look for are specifically tachypnea and rapidly deteriorating hypoxia [6].

Table 3 Bivariate comparison of patients with normal breathing and patients with respiratory distress at the initial ED assessment after drowning

Variable	Normal breathing (*N* = 48)	Respiratory distress (*N* = 23)	*P* value
Age in years, median (IQR)	4.9 (2.5–8.9)	7.0 (2.0–11.0)	0.726
Male gender	25 (52.1)	12 (52.2)	0.994
Water type			
Fresh water	29 (60.4)	12 (52.2)	0.610
Salt water	19 (39.6)	11 (49.8)	
Estimated submersion time > 1 min	11 (22.9)	11 (47.8)	0.034
CPR performed	22 (45.8)	12 (52.2)	0.617
GCS			
15	47 (97.9)	18 (78.3)	0.01
11–14	1 (2.1)	5 (21.7)	
Crepitations			
None	35 (72.9)	6 (26.1)	0.001
Unilateral	5 (10.4)	7 (30.4)	
Bilateral	7 (14.5)	10 (43.5)	
Desaturation < 92%	17 (35.4)	19 (82.6)	< 0.001
Hypothermia < 35 °C	1 (2.1)	2 (8.7)	0.195
Respiratory acidosis: pH < 7.35	13 (27.1)	21 (91.3)	< 0.001
Antibiotic treatment	0	9 (39.1)	0.01
Hospital admission	6 (12.5)	20 (87)	< 0.001

Data are presented as number (%) unless indicated otherwise

ED emergency department, *IQR* interquartile range, *CPR* cardiopulmonary resuscitation, *GCS* Glasgow Coma Scale

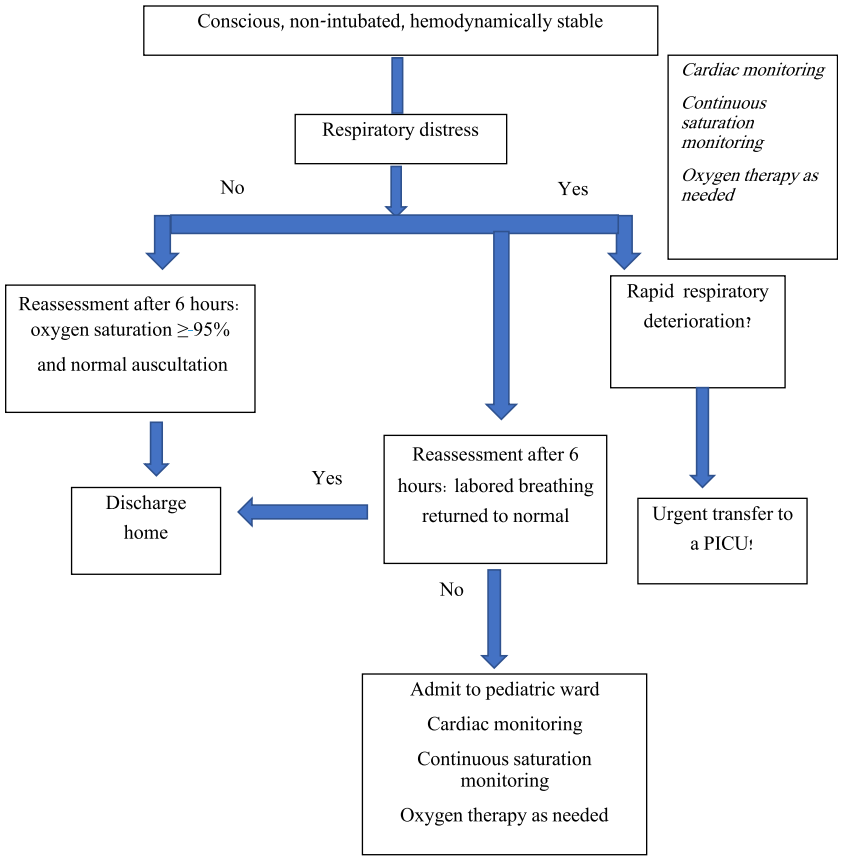

Fig. 1 Algorithm for the disposition of children after drowning

We propose a simple algorithm for asymptomatic to moderately symptomatic children after drowning (Fig. 1). It was designed to guide the ED physician in decision-making with regard to patient disposition, which is especially relevant in hospitals without an intermediate care unit. The algorithm is based on findings of respiratory distress, pulmonary auscultation, and oxygen saturation in the ED. Conscious, non-intubated, and hemodynamically stable patients may be admitted, and asymptomatic patients may be safely discharged home after a 6-h observation period in the ED.

According to the revised policy statement of the American Academy of Pediatrics, for the period 2013–2017, the highest rate of drowning occurred in the 0- to 4-year age group, with children 12 to 36 months of age being at highest risk. Moreover, most infants drown in bathtubs and buckets, whereas the majority of preschool-aged children drown in swimming pools [2, 13].

The median age of our final cohort was 5.0 (IQR 2.5–5.0) and 29 patients (40.8% of the cases) drowned in the sea. This may explain the high median age, compared with the reports in the literature.

Our study has several limitations beyond those inherent to its retrospective design. First, it is a single-center study, reflecting the ED physicians' decisions to admit or discharge based on hospital policy, consequently limiting the ability to generalize the results. Our hospital has no intermediate care unit, which may explain the similarity between the patients admitted to the PICU and those admitted to a pediatric ward. In addition, we have no observation unit, so disposition is generally determined at least 6 h after presentation to the ED. Moreover, some specific details are missing from the reports, such as when each patient was weaned off oxygen. Finally, lung auscultation and assessment of respiratory effort are subjective tests with variations between physicians.

The findings of this study on asymptomatic to moderately symptomatic children after drowning events emphasize the importance of the examination at the ED being equally comprehensive regardless of type and severity of symptoms at presentation. Respiratory distress and lung crepitations were found to be independent predictors for admission. Chest X-rays and blood gas analyses were non-contributory to decision-making of the patient's disposition. We propose an algorithm to guide the ED physician in the management of asymptomatic to moderately symptomatic children who present after drowning.

Authors' contributions Neta Cohen contributed significantly to the planning of the study and the study design, collected data, performed statistical analysis, and did major manuscript preparation. Tali Capua performed statistical analysis and collected data. Sharon Lahat contributed her manuscript expertise. Miguel Glatstein contributed his manuscript expertise. Efraim Sadot contributed to the study design and manuscript editing and contributed his manuscript expertise. Ayelet Rimon contributed

significantly to the study design and manuscript editing and contributed her manuscript expertise.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

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