ORIGINAL RESEARCH

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Investigation of Childhood Drowning Cases Presenting to the Emergency Department of a Tertiary Care Paediatric Hospital Near the Sea Coast

Deniz Kıyısına Yakın Bir Üçüncü Basamak Pediyatri Hastanesinin Acil Servisine Başvuran Çocuk Boğulma Olgularının İncelenmesi

Emre Aygün[1], Mustafa Safa Kasım[1], Mustafa Oğur[2], Ercüment Petmezci[2], Nazan Dalgıç[3]

[1]University of Health Sciences Turkey, Şişli Hamidiye Etfal Training and Research Hospital, Department of Pediatrics, İstanbul, Turkey
[2]University of Health Sciences Turkey, Şişli Hamidiye Etfal Training and Research Hospital, Department of Pediatrics, Division of Pediatric Intensive Care, İstanbul, Turkey
[3]University of Health Sciences Turkey, Şişli Hamidiye Etfal Training and Research Hospital, Department of Pediatrics, Division of Pediatric Infectious Diseases, İstanbul, Turkey

Abstract

Objective: This study aimed to evaluate the epidemiological and clinical features of childhood drowning cases admitted to a seaside tertiary paediatric hospital emergency department and to assess the predictive value of Szpilman classification.

Method: Between 01.01.2021 and 18.09.2024 32 patients aged >1 month and <18 years presenting with drowning were included. Patients were graded according to Szpilman classification (Grade 1-6) and analysed in three groups (Grade 1-2, 3-4 and 5-6). Demographics, vital signs, laboratory and radiological findings, hospitalisation and clinical outcomes were recorded. Discharged and hospitalised patients were compared using univariable exploratory analyses.

Results: The mean age was 9.96±5.53 years and 68.8% were male. Most cases occurred at sea (81.3%), during summer (75%), and 65.6% of presentations were in the noon/afternoon hours. The most common Szpilman grades were Grade 1 (37.5%) and Grade 4 (25.0%). 62.5% of the patients were hospitalised; all Grade 1 patients were discharged and all grade ≥2 patients were hospitalised. Szpilman grade ≥4 (60.0% vs. 0%), pathological chest X-ray (85.0% vs. 0%) and higher lactate (5.79 vs. 2.69 mmol/L) were associated with hospitalisation (p≤0.001

Öz

Amaç: Bu çalışmanın amacı, deniz kenarındaki bir üçüncü basamak pediyatri hastanesinin acil servisine başvuran çocuk boğulma olgularının epidemiyolojik ve klinik özelliklerini değerlendirmek ve Szpilman sınıflandırmasının öngörü değerini belirlemektir.

Yöntem: 01.01.2021-18.09.2024 tarihleri arasında boğulma olgusuyla başvuran 1 aylıktan büyük ve 18 yaşından küçük 32 hasta çalışmaya dahil edildi. Hastalar Szpilman sınıflandırmasına göre derecelendirildi (Derece 1-6) ve üç grupta (Derece 1-2, 3-4 ve 5-6) incelendi. Demografik bilgiler, yaşamsal bulgular, laboratuvar ve radyolojik bulgular, yatış durumu ve klinik sonuçlar kaydedildi. Taburcu edilen ve yatırılan hastalar tek değişkenli keşifsel analizlerle karşılaştırıldı.

Bulgular: Hastaların yaş ortalaması 9,96±5,53 yıl idi ve hastaların %68,8'i erkekti. Olguların çoğu denizde (%81,3) ve yaz aylarında (%75) meydana geldi; başvuruların %65,6'sı öğle/öğleden sonra saatlerindeydi. En sık görülen Szpilman dereceleri Derece 1 (%37,5) ve Derece 4 (%25,0) idi. Hastaların %62,5'i yatırıldı; tüm 1. derece hastalar taburcu edilirken, tüm 2. derece ve üzeri hastalar yatırıldı. Szpilman derecesi ≥4 (%60,0'a karşı %0), patolojik akciğer grafisi

Address for Correspondence: Emre Aygün, University of Health Sciences Turkey, Şişli Hamidiye Etfal Training and Research Hospital, Department of Pediatrics, İstanbul, Turkey
E-mail: emreaygun88@gmail.com **ORCID:** orcid.org/0000-0002-0546-327X
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Abstract

for all). Hospital stay increased with Szpilman grade (Grade 1-2: 2.00 days, Grade 3-4: 4.46 days, Grade 5-6: 39.50 days; p<0.001). Poor outcome (death or sequelae) occurred in four patients (12.5%), three of whom were Grade 5-6 (p=0.003).

Conclusion: The Szpilman classification is a useful tool for estimating clinical outcomes in childhood drowning. Higher Szpilman grade, elevated lactate and pathological radiological findings were associated with hospitalisation. Early recognition of factors associated with poor prognosis may contribute to timely intervention.

Keywords: Drowning, emergency service, pediatrics, prognosis, Szpilman classification

Öz

(%85,0'a karşı %0) ve yüksek laktat (5,79'a karşı 2,69 mmol/L) yatış ile ilişkiliydi (tümü için p≤0,001). Hastanede kalış süresi Szpilman derecesiyle arttı (1-2. derece: 2,00 gün, 3-4. derece: 4,46 gün, 5-6. derece: 39,50 gün; p<0,001). Kötü sonuç (ölüm veya sekel) dört hastada (%12,5) görüldü ve bunların üçü Derece 5-6 idi (p=0,003).

Sonuç: Szpilman sınıflandırması, çocukluk çağı boğulma olgularında klinik sonuçları öngörmede yararlı bir araçtır. Yüksek Szpilman derecesi, yüksek laktat düzeyi ve patolojik radyolojik bulgular yatış ile ilişkiliydi. Kötü prognozla ilişkili faktörlerin erken tanınması, zamanında müdahaleye katkıda bulunabilir.

Anahtar kelimeler: Acil servis, boğulma, pediyatri, prognoz, Szpilman sınıflandırması

Introduction

Worldwide, drowning is an important cause of preventable death in childhood. According to World Health Organization data, approximately 372,000 people die annually due to drowning, and the actual number is thought to be higher due to lack of data in low- and middle-income countries (1). It is reported as the second most common cause of death in children in some countries (2). In children under 15 years of age, drowning causes 140,219 deaths per year, ranking third after AIDS and meningitis (3). In the paediatric group, children aged 1-4 years and adolescents (15-19 years) constitute the highest risk groups (4). Cases occur during daily life in low- and middle-income countries and during recreational activities in high-income countries (1). Drowning is defined as "the process of respiratory impairment caused by immersion in liquid or obstruction of the airways by liquid" (5). Hypoxia and hypothermia can lead to significant complications (6). In children, body structure characteristics cause rapid heat loss and breathing difficulties (7). Hypoxia, hypercapnia and acidosis that develop after drowning can lead to long-term neurological damage by affecting brain functions (6). Cases are more common in boys, in summer and during water activities (2).

Although drowning is a global public health problem, data regarding its epidemiology, clinical course, prognostic factors, and optimal management in children remain limited. Few studies have evaluated pediatric drowning using severity assessment tools such as the Szpilman classification (8). Furthermore, evidence regarding the safe discharge of asymptomatic or mildly symptomatic patients, the role of non-invasive ventilation (NIV) strategies, and predictors of hospitalization and respiratory support requirements remains insufficient (8). Although factors such as submersion duration and water temperature are known to influence outcomes, these variables are frequently unavailable in clinical studies, and the impact of hypothermia and age-specific differences on prognosis remains unclear (8). In addition, prognostic parameters have not been adequately investigated in pediatric drowning victims, and no standardized prognostic model has yet been established (6). Therefore, further studies are needed to improve risk stratification and clinical decision-making in childhood drowning cases.

The hypothesis of our study was that epidemiological and clinical factors would be strongly associated with disease severity and prognosis in children admitted to our seaside tertiary paediatric hospital for drowning. Our main aim was to retrospectively evaluate the epidemiological characteristics, clinical features, management strategies, and outcomes of paediatric drowning cases, as well as to assess the predictive value of the Szpilman classification and identify factors associated with disease severity and prognosis.

Materials and Methods

Study Population and Sample

This study was designed as a single-centre, retrospective study conducted at a tertiary care paediatric hospital. Between 01.01.2021 and 18.09.2024, the electronic medical records of 32 patients admitted to the paediatric emergency department with the complaint of drowning were evaluated. All patients who were admitted to the hospital within the specified date range and met the study criteria were included in the study without sample size calculation. Inclusion criteria were age >1 month and <18 years and presentation to the paediatric emergency department with drowning. Patients aged ≤1 month or ≥18 years were excluded. Drowning is defined as impairment of respiratory function as a result of contact of the respiratory tract with water in any water environment (sea, pool, lake, etc.). Szpilman classification was used for severity assessment. Patients were classified as Grade 1 (normal pulmonary auscultation with coughing), Grade 2 (abnormal pulmonary auscultation with rales in some pulmonary fields), Grade 3 (acute pulmonary oedema without arterial hypotension), Grade 4 (acute pulmonary oedema with arterial hypotension), Grade 5 (isolated respiratory arrest/apnoea) and Grade 6 (cardiopulmonary arrest). The Szpilman classification was assigned retrospectively by the investigators after review of the medical records and was not used for clinical decision-making during patient management.

Operating Procedures

Data collection was performed retrospectively using the relevant International Classification of Diseases, 10th Revision (ICD-10) diagnosis codes (T75.1: Drowning and non-fatal submersion) from the hospital electronic medical record system (health information management system). Demographic characteristics (age, gender), clinical characteristics (nature of the water, season, month, day, hour, presence of chronic disease, initial cardiopulmonary resuscitation (CPR) application, Szpilman classification), vital signs [peak heart rate, respiratory rate, body temperature, oxygen saturation, Glasgow Coma scale (GCS)], laboratory values (arterial blood gas parameters, blood biochemistry) and radiological findings were recorded using a standardised data collection form. Laboratory analyses were performed in the central laboratory of our hospital in accordance with standard protocols. Radiometer ABL800 FLEX analyser was used for arterial blood gas analyses and Beckman Coulter AU5800 autoanalyzer was used for biochemical parameters. Patients were followed up until discharge from the hospital or death. Clinical outcome was recorded as full recovery, recovery with sequelae or death, and poor outcome was defined as death or recovery with sequelae. Radiological evaluation was performed by radiology specialists of our hospital in accordance with standard protocols, and findings such as infiltration, oedema and atelectasis on chest radiographs were classified as “pathological findings”. The reliability of the data collection tools was tested with a pilot study and compared by data extraction by two independent researchers. Owing to the retrospective design, some vital signs and laboratory values were not available for every patient, and analyses were performed with the available data.Troponin was measured in 22 patients (19 hospitalised and 3 discharged). Oxygen saturation could not be measured in patients with cardiopulmonary arrest, and these patients were excluded from the analysis of this variable.

Response Protocol

Patients were divided into two groups according to their clinical status: those discharged from the emergency department and those hospitalised. Randomization was not performed. Hospitalisation and pediatric intensive care unit (PICU) admission decisions were made by the treating physicians based on the overall clinical assessment, including respiratory status, oxygen saturation, neurological findings, radiological abnormalities, and the anticipated risk of clinical deterioration.

The protocols applied to the patients admitted to the intensive care unit were performed in accordance with the standard protocols of the paediatric intensive care unit of our hospital. According to the need for respiratory support, patients were divided into room air, NIV [high-flow nasal cannula (HFNC) or bilevel positive airway pressure (BiPAP)] and invasive mechanical ventilation groups. Antibiotic treatment was initiated when drowning-associated pneumonia was clinically suspected based on respiratory symptoms, abnormal chest radiographic findings, fever, laboratory markers of infection, and physician assessment. Sulbactam-ampicillin, piperacillin-tazobactam, and meropenem were the most commonly prescribed antibiotics. The duration of intensive care unit follow-up and discharge decision were based on the criteria of improvement of the patient’s clinical condition, stabilisation of vital findings and normalisation of laboratory parameters.

Statistical Analysis

IBM SPSS Statistics 25.0 software was used in statistical analyses. Descriptive statistics were presented as number-percentage for categorical variables and mean-standard deviation for continuous variables; the median was also given for length of hospital stay. Demographic and clinical characteristics were presented descriptively, without hypothesis testing. Normal distribution was evaluated by Kolmogorov-Smirnov test. Hospitalised patients and patients discharged from the emergency department were compared using the independent samples t-test or the Mann-Whitney U test for continuous variables, according to the distribution of the data, and Fisher’s exact test for categorical variables. Because the number of patients in several individual Szpilman grades was very small, patients were grouped into three clinically meaningful categories

(Grade 1-2, Grade 3-4 and Grade 5-6). Continuous variables were compared among these groups using One-Way ANOVA and categorical variables using the Fisher-Freeman-Halton exact test. Given the small sample size, multivariable logistic regression analysis was not performed. Factors associated with hospitalisation were examined as exploratory univariable associations using Fisher's exact test, and odds ratios were not estimated because of zero cells. Since only four patients had a poor outcome, this group was compared with patients with good outcome descriptively and with Fisher's exact test only. A p-value <0.05 was considered statistically significant.

Ethical Considerations

Ethical approval for this study was obtained from the Clinical Research Ethics Committee of University of Health Sciences Turkey, Şişli Hamidiye Etfal Training and Research Hospital (approval number: 2024/238, date: October 15, 2024). Due to the retrospective nature of the study using anonymized medical records, the requirement for informed consent was waived by the ethics committee. Personal data were anonymised and coded and analysed to protect the privacy of patients. The study was conducted in accordance with the principles of the Declaration of Helsinki and the good clinical practice guidelines.

Results

The mean age of the 32 patients was 9.96±5.53 years and the majority were boys (68.8%). Most of the cases were drowning in the sea (81.3%), while drowning in the pool was less common (18.8%). Seasonally, the incidents were concentrated in the summer months (75%) and occurred most frequently in July (40.6%). Most of the admissions took place during lunch and afternoon hours (65.6%). Most patients had no chronic diseases (87.5%) and initial CPR was required in only 15.6% of cases. According to the Szpilman classification, most patients were Grade 1 (37.5%), followed by Grade 4 (25.0%) and Grade 3 (15.6%) cases (Table 1).

Compared with patients discharged from the emergency department, hospitalised patients had lower oxygen saturation (86.83% vs. 98.27%, p=0.001), lower GCS scores (12.14 vs. 15.00, p=0.007), lower body temperature (36.28 °C vs. 36.69 °C, p=0.015) and a higher respiratory rate (37.00 vs. 21.45/min, p<0.001). Arterial blood gas parameters showed more pronounced acidosis (pH 7.18 vs. 7.38, p=0.003), higher lactate (5.79 vs. 2.69 mmol/L, p=0.001) and lower bicarbonate (16.85 vs. 22.18 mmol/L, p=0.001) values in hospitalised patients. Glucose (153.55 vs. 101.73 mg/dL,

Table 1. Demographic and clinical characteristics of the patients (n=32)

Parameter	n (%)
Age, years, mean ± SD (min-max)	9.96±5.53 (2.00-17.25)
Sex	
Male	22 (68.8)
Female	10 (31.3)
Type of water	
Sea	26 (81.3)
Pool	6 (18.8)
Season	
Spring (May)	1 (3.1)
Summer (June-August)	24 (75.0)
Autumn (September-October)	6 (18.8)
Winter (December)	1 (3.1)
Month	
May	1 (3.1)
June	4 (12.5)
July	13 (40.6)
August	7 (21.9)
September	4 (12.5)
October	2 (6.3)
December	1 (3.1)
Day of the week	
Monday	5 (15.6)
Tuesday	4 (12.5)
Wednesday	7 (21.9)
Thursday	2 (6.3)
Friday	1 (3.1)
Saturday	7 (21.9)
Sunday	6 (18.8)
Time of presentation	
Morning	4 (12.5)
Noon/afternoon	21 (65.6)
Evening	7 (21.9)
Chronic disease	4 (12.5)
Initial CPR	5 (15.6)
Szpilman grade	
Grade 1	12 (37.5)
Grade 2	3 (9.4)
Grade 3	5 (15.6)
Grade 4	8 (25.0)
Grade 5	1 (3.1)
Grade 6	3 (9.4)

Data are presented as n (%) unless otherwise stated. CPR: Cardiopulmonary resuscitation, SD: Standard deviation p=0.014), aspartate aminotransferase (89.60 vs. 30.82 U/L, p=0.013) and alanine aminotransferase (48.85 vs. 15.18 U/L, p=0.010) levels were also higher in hospitalised patients, whereas peak heart rate, sodium, urea, creatinine and troponin did not differ significantly between the groups. Radiological findings were pathological in 85% of the hospitalised patients, whereas the findings were normal in all discharged patients (p<0.001) (Table 2).

62.5% of the patients were hospitalised and all were followed up in the PICU. The mean duration of hospitalisation was 11.10±19.28 days (median: 4.00 days). When the distribution of respiratory support was analysed, 37.5% of the patients were monitored with room air, 31.3% with HFNC, 15.6% with BiPAP and 15.6% with invasive mechanical ventilation support. All hospitalised patients received respiratory support [NIV: 75%, invasive ventilation (IV): 25%], while those discharged were followed up on room air. Intubation was required in a total of 5 patients (15.6%). Antibiotic use was considered necessary in half of the patients (50%) and sulbactam-ampicillin (68.8%) was preferred most frequently (Table 3).

Szpilman grades were analysed in three groups because of the small number of patients in individual grades. All Grade 1 patients were discharged from the emergency department, whereas all Grade 2 and above patients were hospitalised; accordingly, the hospitalisation rate was 20.0% in the Grade 1-2 group and 100% in the Grade 3-4 and Grade 5-6 groups (p<0.001). The mean length of hospital stay was 2.00±0.00 days in Grade 1-2, 4.46±1.28 days in Grade 3-4 and 39.50±31.61 days in Grade 5-6 (p<0.001). In the Grade 1-2 group, 80.0% of the patients were followed on room air and 20.0% received HFNC. In the Grade 3-4 group, 53.8% received HFNC, 38.5% BiPAP and 7.7% invasive mechanical ventilation, while all patients in the Grade 5-6 group required invasive mechanical ventilation (p<0.001). With increasing severity, pH decreased (7.36, 7.26 and 6.79) and lactate increased (2.36, 4.29 and 13.74 mmol/L) (p<0.001 for both). Glucose rose from 102.65 to 203.50 mg/dL (p=0.001), and the GCS score fell from 14.80 to 4.00 (p<0.001). Oxygen saturation was 97.10% in Grade 1-2 and 87.60% in Grade 3-4; in the Grade 5-6 group, it could be measured in only one patient (60%), since it was not measurable in the three

Table 2. Vital signs and laboratory values at admission

Parameter	All patients (n=32)	Hospitalised (n=20)	Discharged from the ED (n=12)	p
Vital signs				
Peak heart rate (beats/min)	103.72±21.65 (n=29)	107.39±22.07 (n=18)	97.73±20.51 (n=11)	0.244
Respiratory rate (/min)	31.10±10.60 (n=29)	37.00±8.66 (n=18)	21.45±4.74 (n=11)	<0.001
Body temperature (°C)	36.42±0.56 (n=28)	36.28±0.63 (n=19)	36.69±0.19 (n=9)	0.015
SpO_2 (%)[a]	91.17±8.59 (n=29)	86.83±8.21 (n=18)	98.27±1.56 (n=11)	0.001
Glasgow Coma scale	13.13±3.69 (n=29)	12.14±4.26 (n=19)	15.00±0.00 (n=10)	0.007
Arterial blood gas				
pH	7.25±0.20 (n=31)	7.18±0.22 (n=20)	7.38±0.05 (n=11)	0.003
Lactate (mmol/L)	4.69±3.85 (n=31)	5.79±4.34 (n=20)	2.69±1.32 (n=11)	0.001
Bicarbonate (mmol/L)	18.74±5.36 (n=31)	16.85±5.77 (n=20)	22.18±1.66 (n=11)	0.001
Blood biochemistry				
Glucose (mg/dL)	135.16±59.23 (n=31)	153.55±64.98 (n=20)	101.73±24.45 (n=11)	0.014
Sodium (mmol/L)	139.13±4.15 (n=31)	139.75±4.10 (n=20)	138.00±4.17 (n=11)	0.621
Urea (mg/dL)	23.39±6.97 (n=31)	23.70±7.02 (n=20)	22.82±7.17 (n=11)	0.745
Creatinine (mg/dL)	0.58±0.31 (n=31)	0.57±0.26 (n=20)	0.60±0.39 (n=11)	0.822
AST (U/L)	68.74±127.17 (n=31)	89.60±155.38 (n=20)	30.82±13.96 (n=11)	0.013
ALT (U/L)	36.90±63.89 (n=31)	48.85±77.51 (n=20)	15.18±5.40 (n=11)	0.010
Troponin (ng/mL)	34.72±66.62 (n=22)	38.80±71.05 (n=19)	8.83±3.40 (n=3)	0.109
Chest X-ray				<0.001
Normal	15 (46.9)	3 (15.0)	12 (100.0)	
Pathological	17 (53.1)	17 (85.0)	0 (0.0)	

Data are presented as mean ± standard deviation or n (%). Owing to missing data, the number of patients with available measurements varied between variables and is given in parentheses for each continuous variable. Continuous variables were compared using the independent samples t-test or Mann-Whitney U test, and categorical variables using Fisher's exact test. [a]: Patients with cardiopulmonary arrest, in whom SpO_2 was not measurable, were excluded. ED: Emergency department, SpO_2: Peripheral oxygen saturation, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase

Table 3. Hospitalisation and treatment characteristics	
Parameter	**n (%)**
Emergency department outcome	
Discharged from the emergency department	12 (37.5)
Hospitalised	20 (62.5)
Unit of hospitalisation (n=20)	
Paediatric intensive care unit	20 (100.0)
Length of hospital stay, days (n=20)	
Mean ± SD	11.10±19.28
Median	4.00
Respiratory support (n=32)	
Room air	12 (37.5)
High-flow nasal cannula	10 (31.3)
Bilevel positive airway pressure	5 (15.6)
Invasive mechanical ventilation	5 (15.6)
Respiratory support in hospitalised patients (n=20)	
Non-invasive ventilation	15 (75.0)
Invasive mechanical ventilation	5 (25.0)
Antibiotic therapy	16 (50.0)
Antibiotic type (n=16)	
Sulbactam-ampicillin	11 (68.8)
Piperacillin-tazobactam	4 (25.0)
Meropenem	1 (6.3)

Data are presented as n (%) unless otherwise stated. SD: Standard deviation

patients with cardiopulmonary arrest. Chest X-ray was normal in all Grade 1-2 patients and pathological in all patients in the Grade 3-4 and Grade 5-6 groups (p<0.001). All patients in the Grade 1-2 group recovered fully. In the Grade 3-4 group, 92.3% recovered fully and 7.7% recovered with sequelae. In the Grade 5-6 group, one patient (25.0%) recovered fully, two (50.0%) recovered with sequelae and one (25.0%) died (p=0.002) (Table 4).

Factors associated with hospitalisation were evaluated as exploratory univariable associations. Szpilman grade ≥4 was present in 60.0% of hospitalised patients and in none of the discharged patients (p<0.001). Pathological chest X-ray findings were observed in 85.0% of hospitalised patients and in none of the discharged patients (p<0.001). Initial CPR was performed in 25.0% of hospitalised patients and in none of the discharged patients, but this difference was not statistically significant (p=0.130). Odds ratios could not be estimated because of zero cells (Table 5).

A poor outcome was observed in four patients (12.5%); three recovered with sequelae and one died. One of these patients was classified as Grade 4 and three as Grade 6. Szpilman grade 5-6 was more frequent in patients with poor outcome than in those with good outcome (75.0% vs. 3.6%, p=0.003), and all patients in the Szpilman Grade 5-6 group had a GCS score below 8. Pathological chest X-ray findings (100%

Table 4. Clinical characteristics and outcomes according to Szpilman grade groups				
Parameter	**Grade 1-2 (n=15)**	**Grade 3-4 (n=13)**	**Grade 5-6 (n=4)**	**p**
Hospitalisation, n (%)	3 (20.0)	13 (100.0)	4 (100.0)	<0.001
Length of hospital stay, days[a]	2.00±0.00	4.46±1.28	39.50±31.61	<0.001
Respiratory support, n (%)				<0.001
Room air	12 (80.0)	0 (0.0)	0 (0.0)	
High-flow nasal cannula	3 (20.0)	7 (53.8)	0 (0.0)	
Bilevel positive airway pressure	0 (0.0)	5 (38.5)	0 (0.0)	
Invasive mechanical ventilation	0 (0.0)	1 (7.7)	4 (100.0)	
pH	7.36±0.05	7.26±0.10	6.79±0.09	<0.001
Lactate (mmol/L)	2.36±1.20	4.29±1.84	13.74±1.57	<0.001
Glucose (mg/dL)	102.65±23.41	135.02±54.09	203.50±67.90	0.001
Glasgow Coma scale	14.80±0.47	14.12±1.13	4.00±2.00	<0.001
SpO_2 (%)	97.10±2.78	87.60±3.42	60.00[b]	<0.001
Pathological chest X-ray, n (%)	0 (0.0)	13 (100.0)	4 (100.0)	<0.001
Outcome, n (%)				0.002
Full recovery	15 (100.0)	12 (92.3)	1 (25.0)	
Recovery with sequelae	0 (0.0)	1 (7.7)	2 (50.0)	
Death	0 (0.0)	0 (0.0)	1 (25.0)	

Data are presented as mean ± standard deviation or n (%). Continuous variables were compared using One-Way ANOVA and categorical variables using the Fisher-Freeman-Halton exact test. [a]: Hospitalised patients only (n=3, n=13 and n=4, respectively), [b]: Measured in one patient; not measurable in three patients with cardiopulmonary arrest. SpO_2: Peripheral oxygen saturation. Owing to missing data, the number of patients with available measurements varied between variables vs. 46.4%, p=0.104) and hospitalisation (100% vs. 57.1%, p=0.271) did not differ significantly between the outcome groups. Owing to the very small number of patients with poor outcome, regression analysis was not performed and the findings are presented descriptively (Table 6).

Table 5. Factors associated with hospitalisation (exploratory univariable analysis)

Factor	Hospitalised (n=20)	Discharged (n=12)	p
Szpilman grade ≥4	12 (60.0)	0 (0.0)	<0.001
Pathological chest X-ray	17 (85.0)	0 (0.0)	<0.001
Initial CPR	5 (25.0)	0 (0.0)	0.130

Data are presented as n (%). P-values were obtained using Fisher's exact test. Because of the small sample size and the presence of zero cells, odds ratios were not estimated and the associations are presented as exploratory. Comparisons of continuous clinical and laboratory variables between the groups are presented in Table 2. CPR: Cardiopulmonary resuscitation

Table 6. Characteristics of patients with poor and good outcome

Factor	Poor outcome (n=4)	Good outcome (n=28)	p
Szpilman grade 5-6[a]	3 (75.0)	1 (3.6)	0.003
Pathological chest X-ray	4 (100.0)	13 (46.4)	0.104
Hospitalisation	4 (100.0)	16 (57.1)	0.271

Poor outcome was defined as death or recovery with sequelae. Data are presented as n (%). P-values were obtained using Fisher's exact test. Owing to the very small number of patients with poor outcome, no regression analysis was performed and the results are presented descriptively. [a]: All patients with Szpilman grade 5-6 had a Glasgow Coma scale score <8

Discussion

In this study, we evaluated the epidemiological characteristics, clinical presentation, management and outcomes of paediatric drowning cases admitted to a tertiary paediatric hospital located in a coastal region. Our findings support the clinical utility of the Szpilman classification as a practical tool for risk stratification, since higher grades were associated with a greater need for hospitalisation and respiratory support, longer hospital stay and more frequent poor outcome. These findings are particularly relevant given the limited literature evaluating the Szpilman classification in paediatric drowning cases (8). Because demographic, clinical, laboratory, radiological and outcome data were evaluated together in the same cohort, the classification could be compared with parameters that are readily available in the emergency department, such as lactate and chest radiography, both of which were associated with the need for hospitalisation.

The mean age of drowning cases in our study (9.96±5.53 years) was higher than the mean ages of 4.0±3.2 years reported by Loux et al. (9) and 3.9 years reported by Alam et al. (10). This difference may be related to the characteristics of our study area, where most cases occurred at sea rather than in domestic settings. Male predominance in gender distribution (68.8%) was consistent with the literature. Denny et al. (11) reported that approximately 75% of childhood drowning cases were in males, and Tyr et al. (12) reported a similarly high proportion of males (72.3% 0-4 years, 76.0% 5-9 years). Koon et al. (13) also reported male sex as the most frequently identified risk factor.

In 81.3% of our cases, drowning occurred at sea, while pool drownings accounted for 18.8%. Denny et al. (11) reported a high rate of drowning of older children in natural bodies of water (69%), while Loux et al. (9) reported that pool drownings occurred mostly in private pools (65.6%). In the review by Koon et al. (13), drownings in natural water areas were more common, and sea drownings were reported to be 85%, 90% and 76% in Iran, France and South Africa, respectively. Seasonally, cases were concentrated in summer (75%) and especially in July (40.6%). This finding was consistent with the 70% reported by Denny et al. (11) from May to August and the 82% reported by Alam et al. (10) from June to October. Most presentations (65.6%) were during the midday/afternoon hours, which was similar to the 75% observed by Denny et al. (11) between noon and 21:00. Peixoto-Pino et al. (14) reported that drownings are common in summer and in beach and pool environments, and Kamstra et al. (15) indirectly confirmed this seasonal risk with their study in the summer holiday period in Australia. In coastal regions, preventive measures should therefore focus on open water and on the summer months.

In our cohort, Grade 1 was the most common Szpilman grade (37.5%), and the overall distribution was different from the rates reported by Büyük and Çamcı (16) (Grade 1: 26.7%, Grade 2: 13.3%, Grade 5: 53.3%, Grade 6: 6.7%). Peixoto-Pino et al. (14) reported that Grade 1 cases were limited to coughing, while Grade 6 cases required CPR. All Grade 1 patients were discharged, whereas all patients with Grade 2 or higher were hospitalised. Since the Szpilman grade was assigned retrospectively and was not used in admission decisions, this pattern most likely reflects the severity that the treating physicians recognised at presentation, such as abnormal respiratory findings, hypoxaemia and altered consciousness. In other words, the classification summarised the same clinical information on which decisions were based in practice. Büyük and

Çamcı (16) reported that those discharged had a mild clinical picture (GCS 10-15) and those hospitalised had more severe conditions (GCS 3-5). Szpilman and Morgan (17) recommend that patients with grade 3-6 should be hospitalised in the intensive care unit; in our study, all hospitalised patients, including those with Grade 2, were followed in the PICU.

Length of hospital stay increased across the Szpilman groups, and the longest stays were observed in the Grade 5-6 group. Bellini et al. (18) reported that those with pathological chest X-ray findings were hospitalised longer. Poor outcome occurred in four patients, three of whom had presented with cardiopulmonary arrest (Grade 6). All patients in the Grade 5-6 group had a GCS score below 8, and this group included three of the four patients with poor outcome. Büyük and Çamcı (16) reported 83.3% mortality in the Szpilman 3-6 group. Berger et al. (5) reported that the rate of poor outcome was 70% in patients with GCS 3, 0% in patients with GCS 4-15, and the rate of poor outcome reached 100% in patients with pH <7. Reizine et al. (19) showed a strong association of the presence of cardiac arrest at baseline with 28-day mortality [adjusted hazard ratio (aHR) 11.5, 95% CI 2.51-52.43]. Our observations agree with Szpilman and Morgan's (17) emphasis on GCS-based prognostic assessment; however, with only four events, they can only be interpreted descriptively.

In our study, the distribution of respiratory support was room air 37.5%, HFNC 31.3%, BiPAP 15.6% and IV 15.6%. Şık et al. (20) reported that all 25 children with Grade 3-4 drowning-related pulmonary edema were treated with BiPAP, with none subsequently requiring invasive mechanical ventilation. The type of respiratory support changed with Szpilman grade. Most patients in the Grade 1-2 group remained on room air, HFNC and BiPAP were mainly used in the Grade 3-4 group, and all Grade 5-6 patients required IV. Non-invasive support was therefore sufficient for most patients up to Grade 4. Capela et al. (21) reported that IV was required in 83% of severe cases, whereas supplemental oxygen alone (26%) was sufficient in mild cases. Intubation was needed in 15.6% of our patients; one of them was in Grade 4 and the remaining four were in Grade 5-6. Reizine et al. (19) reported the association of first-day invasive mechanical ventilation with mortality. Oxygen saturation decreased with increasing severity and could not be measured in patients with cardiopulmonary arrest. Dezfulian et al. (22) emphasised that cardiac arrest after drowning is usually caused by severe hypoxaemia and stressed the importance of early oxygen therapy.

Hospitalised patients had lower pH and higher lactate levels than discharged patients, and both parameters worsened across the Szpilman groups, with the most pronounced acidosis and hyperlactataemia in the Grade 5-6 group. Berger et al. (5) reported that the risk of neurological damage/death was significantly higher in children with pH <7 [relative risk (RR) 12.3, 95% CI 4.17-36.49], and that the risk of poor outcome increased 9-fold in patients with lactate >14 mmol/L. Jeswani et al. (23) also showed that pH <7 was associated with poor outcomes in children. Sacco and Aquila (24) emphasised that lactate levels are significantly increased in hypoxia and indicate the severity of the condition. Since blood gas results are available within minutes of arrival, pH and lactate may complement the Szpilman grade in the early assessment of severity. Because of the small number of poor outcomes, we did not evaluate prognostic cut-off values for these parameters.

Chest radiographs were normal in all Grade 1-2 patients and pathological in all patients with Grade 3 or higher. Pathological findings were present in 85% of hospitalised patients and in none of the discharged patients, but they were not significantly associated with poor outcome. Bellini et al. (18) showed that pathological chest X-ray increased the likelihood of hospitalisation (p=0.023). Peri et al. (25) reported that pathological chest X-rays (bilateral opacities) were seen in 61% of intensive care unit patients, and Jeswani et al. (23) reported that abnormal findings were associated with poor prognosis. The lack of such an association in our cohort is probably related to the small number of patients with poor outcome. Szpilman and Morgan (17) also recommended chest X-ray to evaluate pulmonary oedema in all patients and our findings support this approach.

Antibiotics were administered to 50% of the patients and sulbactam-ampicillin (68.8%) was preferred most frequently. Although treatment was started only when drowning-associated pneumonia was suspected, this rate is relatively high and may reflect a low threshold for treatment in patients with abnormal chest radiographs. Cousin and Pittet (26) reported that amoxicillin-clavulanate (78-94%) was mostly used in drowning-related pneumonia.

Study Limitations

Limitations of our study include its retrospective single-centre design and relatively small sample size, which may limit the generalisability of the findings. The low number of patients with poor outcome (n=4) and the small number of patients in some Szpilman grades did not allow multivariable analysis. The associations reported here are therefore exploratory and should not be interpreted as independent predictors of hospitalisation or outcome. Another limitation is that the Szpilman classification was assigned retrospectively based on documented clinical findings and was not routinely recorded during patient management. Some vital signs and laboratory values were missing because of the retrospective design, and oxygen saturation could not be measured in patients with cardiopulmonary arrest. In addition, important variables known to influence prognosis, such as submersion duration, water temperature, bystander resuscitation quality and prehospital interventions, were not consistently available in the medical records and therefore could not be analysed. Patients were followed only until hospital discharge, so long-term neurological outcomes could not be assessed. Despite these limitations, the study provides detailed clinical, laboratory, radiological and outcome data from a paediatric cohort and contributes additional evidence regarding the prognostic value of the Szpilman classification in childhood drowning. Future multicentre prospective studies with larger sample sizes and more comprehensive data collection are needed to validate these findings and support the development of evidence-based guidelines for paediatric drowning management.

Conclusion

We found that the Szpilman classification was useful for estimating the clinical course and outcome of drowning children treated in a coastal paediatric referral hospital. Drowning cases were more common in boys, in the summer months and at sea. Higher Szpilman grade, elevated lactate levels and pathological chest radiographic findings were associated with the need for hospitalisation, and poor outcome was seen mainly in patients presenting with cardiopulmonary arrest. As the number of patients was small, these associations should be confirmed in larger prospective studies. Early recognition of patients at risk of poor outcome may contribute to timely intervention and the prevention of possible complications.

Ethics

Ethics Committee Approval: Ethical approval for this study was obtained from the Clinical Research Ethics Committee of University of Health Sciences Turkey, Şişli Hamidiye Etfal Training and Research Hospital (approval number: 2024/238, date: October 15, 2024).

Informed Consent: Due to the retrospective nature of the study using anonymized medical records, the requirement for informed consent was waived by the ethics committee.

Footnotes

Authorship Contributions

Surgical and Medical Practices: E.A., M.O., E.P., N.D., Concept: E.A., N.D., Design: E.A., M.S.K., N.D., Data Collection or Processing: E.A., M.S.K., M.O., E.P., Analysis or Interpretation: E.A., M.O., E.P., N.D., Literature Search: E.A., M.S.K., Writing: E.A., N.D.

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