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Original Research

Drowning Injuries: Analysis of a Decennial Air Medical Rescue Center Experience

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A B S T R A C T

Objective: Drowning is one of the leading injury death causes in younger children. Common intensive care measures seem not to improve neurologic outcome, and early prognostic options appear partially unreliable. Therefore, we evaluated a cohort of drowning patients cotreated by a helicopter emergency medical service regarding typical incident constellations, early and subsequent prognostic options, and relevant interventions.

Methods: All patients prehospitally cotreated by helicopter emergency medical service “Christoph 4” in primary missions because of drowning incidents during a 10-year period were evaluated. Patient, pre-hospital, and clinical data were recorded retrospectively; correlations and prognostic values were evaluated with appropriate statistical tests.

Results: Fifty-one patients were included. Various examination results (several vital, neurologic, and laboratory parameters) and sufficient prehospital first aid measures were significantly correlated with the final outcome ($P < .05$, respectively). Aspartate aminotransferase and alanine aminotransferase values precisely discriminated between the final outcome groups ($P = .001$ and area under the receiver operating characteristic curve = 1.0 in both cases).

Conclusion: Aspartate aminotransferase and alanine aminotransferase values were the most useful predictors of outcome in our study. Sufficient prehospital first aid measures were correlated with improved outcome. Regular first aider training is recommended.

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According to estimations, in the year 2012, 372,000 people died worldwide because of drowning incidents.¹ Younger children are especially at noticeable risk. Referencing an overview of selected death causes, “accidental drowning and submersion” were the second most common “external causes of morbidity and mortality” in children aged 1 to 4 years in Germany in 2010.² Data referring to drowning as the most frequent (unintentional) injury death cause in younger children were published for Australia³ and parts of the United States.⁴ The basic pathophysiology of drowning injuries has

been repeatedly illustrated,^{5–7} and several prognostic and therapeutic approaches have been evaluated.^{8–10} However, intensive care therapy options seem not to improve the neurologic outcome.¹¹

Consequently, structured prevention, sufficient prehospital treatment, and reliable prognosis of outcome are of great importance. The European Resuscitation Council Guidelines for Resuscitation 2010 displayed decided treatment recommendations for drowning injuries,¹² and various preventive approaches were described in detail.³ However, reliable prediction of the neurologic outcome in (pediatric) drowning patients still appears difficult, especially during early treatment stages,^{7,13} and prevention efforts need to be adjusted precisely.

Consequently, we evaluated a record of drowning incidents treated by an air medical service regarding typical incident

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constellations, potential prognostic parameters, and prehospital interventional options.

Methods

Ethical Approval

This study was approved by the chairman of the Ethics Committee of Hannover Medical School, Hannover, Germany, on August 29, 2006.

Study Design and Data Sources

Cases were identified retrospectively through the electronic documentation system of helicopter emergency medical service (HEMS) “Christoph 4.” Inclusion criteria were case classification as “drowning” by the responsible emergency physician during the years 1995 to 2004, prehospital cotreatment of respective patients by HEMS “Christoph 4,” primary mission character, and known final outcome. Patients admitted to other hospitals than Hannover Medical School were excluded.

All data were acquired retrospectively. Patient, setting, and prehospital data were derived primarily from a direct data export of the electronic HEMS documentation system (Microsoft Excel [Microsoft, Redmond, WA] file format); complementary data were obtained from archived records. Clinical data were derived from available hospital medical files.

Patient and Setting Data

Patient and setting data included patient age and sex, incident location category, and daytime and date of rescue operation.

Prehospital Data

Prehospital data included presence and quality of first aid measures, prehospital vital signs (respiratory status and electrocardiographic [ECG] finding) and neurologic conditions (Glasgow Coma Scale [GCS] and pupillary status) at HEMS arrival, and prehospital treatment. Furthermore, operation durations, mode of transportation, and prehospital outcome were evaluated. First aid measures were assessed and documented by the emergency physician.

Clinical Data

Recorded clinical data included clinical course, vital parameters on admission (circulation and patient temperature), results of imaging and diagnostic studies (chest X-ray, diagnostic imaging of the head, electroencephalogram, and laboratory parameters), and final outcome.

Parameter Classification

Several parameters were dichotomized or categorized as follows: age (< 18 years: “children” or “minors,” ≥ 18 years: “adults”), incident date (March to May: “spring,” June to August: “summer,” September to November: “autumn,” December to February: “winter”), and ECG finding (asystole and ventricular fibrillation: “insufficient,” other findings: “potentially sufficient”). Patient temperature was classified according to previously published reports¹⁴ (≥ 35.0°C [≥ 95.0°F]: “normothermia,” ≥ 32.0°C and < 35.0°C [≥ 89.6°F and < 95.0°F]: “mild hypothermia,” ≥ 28.0°C and < 32.0°C [≥ 82.4°F and < 89.6°F]: “moderate hypothermia,” and < 28.0°C [< 82.4°F]: “severe hypothermia”).

The final outcome was categorized as “good” (survival without relevant neurologic impairment or survival with mild neurologic impairment) or “bad/poor” (postapallic syndrome or comparable outcome or death) after previous publications.^{10,15}

Data Processing and Statistical Analysis

Data were recorded, structured, and examined with IBM SPSS Statistics Version 21.0.0.0 (IBM, Armonk, NY). Correlations of categorized parameters were examined with the chi-square test or the Fisher exact test if more than one fifth of all cells had an expected count of less than 5. The differences of quantitative parameters for 2 groups were examined with the Mann-Whitney *U* test (asymptotic significance). Statistic significance was assumed for values of $P < .05$ in all cases.

Laboratory parameters strongly correlating with the final outcome ($P \leq .001$) were additionally evaluated as test variables regarding the final outcome in receiver operating characteristic analyses (distribution assumption: “nonparametric,” confidence level: 95%). Calculated values were area under the receiver operating characteristic curve, “optimal” cutoff point using the Youden index, and associated sensitivity and specificity values.

Results

Patients

Fifty-one patients (34 men and 17 women) were included. The mean age was 25.4 ± 26.9 years; 29 patients were less than 18 years of age, and 20 patients were younger than 4 years of age. Sex proportions did not significantly differ for different age groups ($P > .05$); children had significantly better final outcomes than adults ($P < .001$).

Operation Times and Locations

Of the rescue operations, 41.2% occurred in summer (21/51), and 45.1% were started between 2 and 6 PM (23/51); 35.3% (18/51) of incidents were located in households, whereas 29 cases (56.9%) occurred elsewhere. In 4 cases, the incident location category was not ascertainable. All patients were victims of freshwater drownings.

The season, daytime (aggregated in 4-hour blocks starting at midnight), and incident location categories did not correlate with defined age groups ($P > .05$ in all cases). However, drowning incidents in children under 4 years were significantly more often located in households compared with older patients ($P < .001$). Distributions of age groups, location categories, and seasons are summarized in Table 1.

Operation Durations and First Aid Measures

The mean flight duration to incident location was 8.8 ± 3.3 minutes, whereas the mean duration on scene was 22.2 ± 13.8 minutes. In 27 of 29 minors, sufficient first aid measures were taken, whereas in 10 of 20 adults, no sufficient initial measures were adopted ($P = .001$, 2 missing cases). Sufficient first aid measures significantly correlated with better final outcomes in our patients ($P < .001$) as presented in Table 2.

Prehospital Examination and Treatment

Documented respiratory (apnoea vs. spontaneous respiration, $n = 44$), circulatory (insufficient vs. potentially sufficient ECG finding, $n = 43$), neurologic (GCS > 3 vs. = 3, $n = 51$), and pupillary conditions (present vs. absent light reflex, $n = 47$; narrow or normal sized vs. wide pupils, $n = 46$) were recorded. Children more often showed spontaneous respiration, potentially sufficient ECG findings, GCS > 3, present pupillary light reflexes, and normal-sized pupils in comparison with adults ($P < .001$ in all cases). All factors significantly correlated with the final outcome ($P < .001$ in all cases) as shown in Table 2.

Deduced from ECG findings, 26 patients were in cardiac arrest at HEMS arrival. In 19 of these patients, cardiopulmonary resuscitation (CPR) was initiated or continued by HEMS. One patient in this subgroup survived with mild neurologic impairment in contrast to

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