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Observed long-term mortality after 18,000 person-years among survivors in a large regional drowning registry[☆,☆☆]

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ABSTRACT

Aim: Long-term outcomes beyond one year after non-fatal drowning are uncharacterized. We estimated long-term mortality and identified prognostic factors in a large, population-based cohort.
Methods: Population-based prospective cohort study (1974–1996) of Western Washington Drowning Registry (WWDR) subjects surviving the index drowning through hospital discharge. Primary outcome was all-cause mortality through 2012. We tabulated Utstein-style exposure variables, estimated Kaplan–Meier curves, and identified prognostic factors with Cox proportional hazard modeling. We also compared 5-, 10-, and 15-year mortality estimates of the primary cohort to age-specific mortality estimates from United States Life Tables.
Results: Of 2824 WWDR cases, 776 subjects (5[IQR 2–17] years, 68% male) were included. Only 63 (8%) non-fatal drowning subjects died during 18,331 person-years of follow-up. Long-term mortality differed by Utstein variables (age, precipitating alcohol use, submersion interval, GCS, CPR, intubation, defibrillation, initial vital signs, neurologic status at hospital discharge) and inpatient markers of illness severity (mechanical ventilation, vasopressor use, seizure, pneumothorax). Survival differed by age (HR 1.04;95%CI 1.03–1.05), drowning-related cardiac arrest (HR 3.47;95%CI 1.97–6.13), and neurologic impairment at hospital discharge (HR 5.10;95% CI 2.70–9.62). In adjusted analysis, age (HR 1.05;95%CI 1.03–1.06) and severe neurologic impairment at discharge (HR 2.31;95%CI 1.01–5.28) were associated with long-term mortality. Subjects aged 5–15 years had higher mortality risks than those calculated from Life Tables.
Conclusion: Most drownings were fatal, but survivors of non-fatal drowning had low risk of subsequent long-term mortality similar to the general population that was independently associated with age and neurologic status at hospital discharge.

Introduction

Nearly 400,000 annual deaths worldwide are from unintentional drowning.[1] This likely underestimates true mortality, since drowning fatalities can be misclassified with International Classification of Disease (ICD) codes, and fatalities from floods, tsunamis, and water transport accidents are not included in this estimate.[2] The overall annual mortality rate of unintentional drowning in developed nations ranges from 0.56 per 100,000 (United States) to 1.2 per 100,000 (United Kingdom).[3] Annual mortality in developing nations within Central America and Africa is 10-fold to 20-fold higher.[1] Mortality estimates from drowning are imprecise, but even less is known about the long-term outcomes of non-fatal drowning. A few observational studies report one year mortality,[4,5] but most outcomes in the drowning literature are limited to hospital discharge.[6–8] Large-scale epidemiological studies of long-term mortality are lacking, which poses challenges to providing accurate prognostic information to caregivers of drowned patients,

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understanding the true burden of injury, and informing policy interventions.

Using data from a large regional drowning registry, we estimated the long-term mortality of subjects that survived the index drowning event. We hypothesized that subjects with sequelae of more severe drowning injury were at higher risk of long-term mortality.

Methods

The Michigan State University Institutional Review Board (IRB) approved this study, as well as original IRBs at Seattle Children's Hospital, Washington State IRB, and participating hospitals.

Data source

The Western Washington Drowning Registry (WWDR) is a large, regional, drowning registry that has previously been described in detail.[6,10] It contains subjects with fatal and non-fatal drowning in King, Pierce, and Snohomish counties between January, 1974 and July, 1996. These counties include the city of Seattle and contained 2,559,136 residents in 1990.[9] Their western border is temperate coastline along the Pacific Ocean, and their eastern edge is the Cascade Mountains, which feed major rivers, tributaries, and hundreds of lakes.

WWDR cases were ascertained by searching for keywords and ICD-9 codes in investigative and autopsy reports of each county's medical examiner office; hospital records from all 26 acute care hospitals (including tertiary care centers; the regional children's hospital; and regional trauma centers); incident reports from the four regional Emergency Medical Services (EMS) agencies; Washington State death certificates; and state civilian hospital discharges. Research personnel abstracted detailed data about subjects; drowning events; prehospital course; and hospital course from these sources.

Study design and population

This was a secondary analysis of an established cohort of subjects experiencing a drowning event. All subjects surviving the index drowning event through a healthcare encounter (Emergency Medical Services [EMS] and/or Emergency Department [ED] evaluation with/without hospitalization) were included. Subjects who experienced fatal drowning or who expired at any point during the index healthcare encounter were excluded.

Study definitions and outcomes

Drowning is the process leading to some degree of primary respiratory impairment from submersion or immersion in liquid medium.[11] In keeping with Utstein-style recommendations for uniform reporting of data from drowning, we do not use the terms 'dry drowning', 'wet drowning', or 'near-drowning'.[11] In other words, drowning victims may or may not survive the event, but irrespective of outcome, they have been involved in a drowning incident.

We used Utstein-style guidelines[11] to catalog and organize the exposure variables in this registry. We collected victim information (sex, age, ethnicity, date of incident, precipitating event), scene information (witnessed event, body of water, bystander resuscitation, EMS involvement, prehospital interventions, prehospital neurologic status), Emergency Department information (vital signs, interventions, neurologic status), and hospital course (ventilation requirements, complicating illnesses, final neurologic status at discharge). In this registry, neurologic status at hospital discharge was graded as normal, mild impairment, moderate impairment, severe impairment, and vegetative state, according to the Pediatric Cerebral Performance Category (PCPC).[10,12]

The primary outcome was all-cause mortality after the index drowning event. Long-term mortality through 2012 was assessed by linking registry data to the National Death Index (NDI) (National Center for Health Statistics, Hyattsville, MD).[13] Subjects' given name and surname, middle initial (if known), birth date, and sex were submitted to NDI at the National Center for Health Statistics (NCHS). After a preliminary search to identify potential matches (at least one matching criterion), NCHS uses a probabilistic matching system to generate final results. High-probability matched cases are denoted in NDI retrieval data.

Statistical analyses

Analyses were performed with SAS 9.4 (SAS, Cary, NC). We tabulated Ustein-style drowning variables and performed descriptive statistics. We tabulated exposure variables (patient characteristics, drowning event characteristics, EMS evaluation/treatment, ED evaluation/treatment, and hospital course) according to mortality status. We used chi-square, rank-sum, and t-tests to test for differences between long-term survivors and non-survivors, appropriate to each variable. Kaplan–Meier curves were constructed for *a priori* selected key patient characteristics: age, sex, drowning-related cardiac arrest, and neurologic status at hospital discharge. Differences in mortality were tested with the log-rank test. Cox proportional hazard modeling identified prognostic factors associated with long-term mortality. First, univariate screening identified potentially significant predictors ($p \leq 0.20$) of long-term mortality among 17 Utstein variables of interest: age, sex, pre-drowning impaired neurologic function, witnessed drowning, ice on water, submersion interval (minutes), drowning-related cardiac arrest (prehospital or ED CPR), attempted prehospital or ED intubation, initial body temperature in the ED, mechanical ventilation, inpatient complications or markers of illness severity (vasopressors, seizure, shock, pneumothorax, pulmonary edema, disseminated intravascular coagulation [DIC]), and neuro status at hospital discharge. Backwards variable selection ($p \leq 0.20$ to enter; $p \leq 0.05$ to stay) developed a final multivariable Cox model with those variables missing <25% data.

Since all subjects in this dataset were exposed to drowning, their long-term mortality experience was compared to an external standard. Given the broad range of subject ages (0–90 years) and periods (1974–1996) in this cohort, generating an indirect standardized mortality ratio was not feasible. Instead, we calculated exact binomial confidence intervals (Clopper–Pearson method) of the observed 5-, 10-, and 15-year mortality experience of the drowning cohort by age, and compared these to age-specific mortality rates estimated from 1985 United States Life Tables (Centers for Disease Control and Prevention).[14]

Finally, to discern whether the index drowning event was associated with specific causes of death or plausibly contributed to long-term mortality, we tabulated ICD codes listed as single cause of death in NDI.

Results

Of 2824 subjects with drowning events, 1205 (43%) were evaluated by EMS, 1064 (38%) evaluated in an ED, and 834 (30%) hospitalized. (Fig. 1) Many subjects used varying combinations of healthcare resources. For example, some subjects were evaluated only by EMS (7%), only in the ED (11%), or both, regardless of whether they were transported by EMS. Subjects were also transferred between facilities laterally or as direct admissions (10%). In total, 776 (27%) survived the index drowning event with or with-