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Review article

Predicting outcome of drowning at the scene: A systematic review and meta-analyses☆

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ABSTRACT

Objective: To identify factors available to rescuers at the scene of a drowning that predict favourable outcomes.
Design: Systematic review and meta-analysis.
Data sources: PubMed, Embase and Cochrane Library were searched (1979–2015) without restrictions on age, language or location and references lists of included articles.
Study selection: Cohort and case–control studies reporting submersion duration, age, water temperature, salinity, emergency services response time and survival and/or neurological outcomes were eligible. Two reviewers independently screened articles for inclusion, extracted data, and assessed quality using GRADE. Variables for all factors, including time and temperature intervals, were categorized using those used in the articles. Random effects meta-analyses, study heterogeneity and publication bias were evaluated.
Results: Twenty-four cohort studies met the inclusion criteria.

The strongest predictor was submersion duration. Meta-analysis showed that favourable outcome was associated with shorter compared to longer submersion durations in all time cutoffs evaluated: ≤5–6 min: risk ratio [RR] = 2.90; (95% confidence interval [CI]: 1.73, 4.86); ≤10–11 min: RR = 5.11 (95% CI: 2.03, 12.82); ≤15–25 min: RR = 26.92 (95% CI: 5.06, 143.3). Favourable outcomes were seen with shorter EMS response times (RR = 2.84 (95% CI: 1.08, 7.47)) and salt water versus fresh water 1.16 (95% CI: 1.08, 1.24). No difference in outcome was seen with victim's age, water temperatures, or witnessed versus unwitnessed drownings.
Conclusions: Increasing submersion duration was associated with worse outcomes. Submersion durations <5 min were associated with favourable outcomes, while those >25 min were invariably fatal. This information may be useful to rescuers and EMS systems deciding when to perform a rescue versus a body recovery.

Introduction

The World Health Organization estimates 372,000 people die annually from drowning worldwide.[1] The real number is probably 2–5 times higher. Rescuers save many lives, but some die in the attempt.[2–6] Rescuers with a duty to respond, such as firefighters, policemen and lifeguards, are trained to decide if and how to perform a rescue and to consider the safety of a rescue.[7] In some

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situations the risk of a rescue has to be weighed against the victim's chance of survival. Many issues affect the decision, including the safety, training and physical condition of the rescuer, environmental conditions and available resources. In some situations, the decision needs to be made to change from a rescue to a body recovery. Such a decision may have legal consequences.[8] Knowing what factors might predict a favourable outcome for a drowning victim could help inform a rescuer's decision-making in such situations.

Many drowning studies have reported on outcomes of survival with or without qualifying neurologic outcomes, evaluating demographic, scene, medical and/or treatment factors as predictors of outcome. The methodology and quality of these studies vary widely and conclusions are occasionally contradictory. There are no comprehensive systematic reviews and meta-analyses of factors associated with drowning outcomes. This study's objective was to systematically review existing literature and conduct meta-analyses to determine what factors known to rescuers (age of victim, emergency medical service (EMS) response time, duration of submersion, salinity of water, water temperature, and if the event was witnessed) are associated with favourable outcomes.

Methods

This review was based on the guidelines from the International Liaison Committee for Resuscitation (ILCOR) and Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group, then registered on the ILCOR on-line Scientific Evidence Evaluation and Review System[9,10,11] Meta-analyses were then conducted.

Eligibility

PubMed, Embase and Cochrane Library were searched systematically for studies published between 1979 and 2015 (Supplementary File 1). Reference lists of included articles were hand searched for additional relevant studies. Eligible studies for the systematic review were cohort and case–control studies in all languages. Studies were selected for inclusion if they reported favourable and unfavourable outcomes of drowning victims for at least one of the following six factors: (i) victim's age, (ii) whether the drowning event was witnessed, (iii) submersion duration, (iv) salinity of water (fresh versus salt), (v) water temperature, and (vi) the emergency medical service's response time. If available data did not allow calculation of relative risk, authors were contacted for additional information. For studies from overlapping populations, the study with the largest sample that evaluated the most factors of interest was selected.

Studies were excluded if the study (i) design lacked a comparison group (e.g. case reports, case series), (ii) contained insufficient information to calculate a relative risk (RR) and the required data were unavailable after contacting the author(s), (iii) reported only highly selected patient treatment groups (e.g. those receiving invasive ventilation or extracorporeal membrane oxygenation), and (iv) was published as an abstract only or in conference proceedings. There were no age, setting or language restrictions.

Factor variables and outcome measures

Age was categorized as child or adult using the age definitions in the studies identified. The following categories were used for water salinity: salt water for salt water and oceans versus fresh water for all other waters (fresh, lake, river, well, pond, stagnant); witnessed status: Yes or No; and EMS response time < or ≥9 min as used in the studies reviewed. Time and temperature intervals were categorized using the intervals used in the articles. Submersion duration intervals were grouped as short (≤ or >5–6 min), intermediate (≤ or >10 min) or prolonged (≤ or >15–25 min). Water temperature intervals used in articles were also grouped as < or ≥ 6–8 °C, and < or ≥15–17 °C.

Critical outcomes were defined a priori as (i) good versus bad neurological outcome/death and (ii) survival versus death at either hospital discharge or one month or one year after hospital discharge as reported in each study. For the analyses, good neurologic outcome or survival was categorized as favourable outcomes. Bad neurologic outcome or death was categorized as poor outcomes.

Data extraction

Two authors (LQ and JB) screened the studies by title and abstract for eligibility. GDP resolved disagreements. Reviewers (RL, JB, LQ) collected data: author, year of publication, study design, study population (including age group, data source (emergency department, hospital, drowning data base, other)), factors studied, outcome definition and risk ratio. If a study provided data for survival/death as well as for good/bad outcome the study was categorized using only the good/bad outcomes.

Quality assessment

Three authors (JB, LQ and PM) assessed the risk of bias for each study using the QUIPS tool for prognostic studies (study participation; study attrition; prognostic factor measurement; outcome measurement; and statistical analysis and reporting) For each outcome and factor variable, they, in accordance with GRADE, for each outcome and factor variable made an overall assessment of the quality of evidence based on risk of bias, inconsistency, indirectness, imprecision, publication bias, and possible rating up criteria.[12,13]

Statistical analysis

Findings of included studies were pooled using RR. All analyses were conducted using random and fixed effect models; both models are presented in the forest plots (DerSimonian and Laird (D + L) = Random effects, Mantel–Haenszel (M–H) = Fixed effect); however, all interpretations were based on the random effects model estimates due to the observed heterogeneity of effects and plausibility. Studies with a zero cell were included by adding 0.5 to all cell counts to permit calculation of an effect measure and 95% confidence interval.[14]

Between-study heterogeneity was calculated using the I^2 statistic. Heterogeneity was deemed low if it was <25% and considerable if it was >75%. Three tests were conducted to assess publication bias: Funnel plots were created for visual assessment. When there were ≥7 studies, the Begg adjusted rank correlation test, a numerical analogue to the funnel plot and the Egger regression asymmetry test were conducted.[15,16] Analyses were conducted using STATA 12.

This study of published literature did not require Institutional Review Board approval.

Results

The database search identified 1542 unique papers of which 349 related to drowning. After reading the title, 127, after reading the abstract, 47, and after reading the full text, 24 papers were selected (Supplementary File 2). All were cohort studies. Eight studies included multivariate analyses for some factors.

Description of each study's author, year of publication, study location, study design, study population, sample size, factor definition, outcome definition, percent of poor outcome, and RR for each factor are listed in Table 1A–I.