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Predicting in-hospital mortality for initial survivors of acute respiratory compromise (ARC) events: Development and validation of the ARC Score☆

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ABSTRACT

Aim: Acute respiratory compromise (ARC) is a common and highly morbid event in hospitalized patients. To date, however, few investigators have explored predictors of outcome in initial survivors of ARC events. In the present study, we leveraged the American Heart Association's Get With The Guidelines® - Resuscitation (GWTG-R) ARC data registry to develop a prognostic score for initial survivors of ARC events.

Methods: Using GWTG-R ARC data, we identified 13,193 index ARC events. These events were divided into a derivation cohort (9807 patients) and a validation cohort (3386 patients). A score for predicting in-hospital mortality was developed using multivariable modeling with generalized estimating equations.

Results: The two cohorts were well balanced in terms of baseline demographics, illness-types, pre-event conditions, event characteristics, and overall mortality. After model optimization, nine variables associated with the outcome of interest were included. Age, hypotension preceding the event, and intubation during the event were the greatest predictors of in-hospital mortality. The final score demonstrated good discrimination in both the derivation and validation cohorts. The score was also very well calibrated in both cohorts. Observed average mortality was <10% in the lowest score category of both cohorts and >70% in the highest category, illustrating a wide range of mortality separated effectively by the scoring system.

Conclusions: In the present study, we developed and internally validated a prognostic score for initial survivors of in-hospital ARC events. This tool will be useful for clinical prognostication, selecting cohorts for interventional studies, and for quality improvement initiatives seeking to risk-adjust for hospital-to-hospital comparisons.

Introduction

Acute respiratory compromise (ARC) is a common trigger for hospital-wide rapid response team activation and carries a significant morbidity/mortality burden.[1,2] Patients suffering from ARC frequently require the initiation of mechanical ventilation and admission to an intensive care unit. Not only are these patients at risk from delayed recognition of clinical decompensation and complications in the peri-intubation period (e.g. hypotension, cardiac arrest),[3] but also often go on to develop multi-organ dysfunction.[4] Despite their strong association with poor outcome, ARC events

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in hospitalized patients are not a well-studied entity. To date, the natural history of hospital ARC events and their relationship to in-hospital mortality has not been well described.

Prognostic scores play an important role in critical care medicine where they are used to guide selection of advanced therapies, aid families with difficult decision making, and select patients for enrollment in clinical trials. Using the nationwide Get with the Guidelines Resuscitation® (GWTG-R) cardiopulmonary arrest registry, investigators have recently developed the Cardiac Arrest Survival Post-Resuscitation In-hospital (CASPRI) score[5,6] and the Good Outcome Following Attempted Resuscitation (GO-FAR) score[7] to assist with predicting outcomes following in-hospital cardiac arrest. In addition to their prognostic utility, these scores also provide a mechanism for hospital-to-hospital adjusted outcome comparisons to aid in the optimization of quality within health care systems.[8]

While a number of clinical models exist for predicting mortality following cardiac arrest, no models exist to assist with prognostication for patients who have suffered and survived an ARC event. The relatively common occurrence of ARC, coupled with its high morbidity and cost to the healthcare system,[4,9] justifies further investigation into the predictors of poor outcome following such events. In the present study, we aim to use the GWTG-R ARC database to develop a useful prognostic score for initial survivors of an in-hospital ARC event.

Methods

The GWTG-R database is a large, prospective, quality-improvement registry of in-hospital cardiac arrests, medical emergency team activations, and ARC events sponsored by the American Heart Association. Hospitals participating in the registry submit clinical information regarding the medical history, hospital care, and outcomes for consecutive patients using an online, interactive case report form and Patient Management Tool (Quintiles, Cambridge, Massachusetts). The design, data collection, and quality control of the GWTG-R repository have been described previously.[10,11,12] In the GWTG-R database, information on ARC events has been captured since 2004. As of the time of this analysis, over 300 unique hospital sites participate in data collection for the GWTG-R ARC data registry. In our study, we included all adult ARC events occurring between June 2005 and June 2015. Authors AM and LA had access to all of the data in the study and take responsibility for the integrity of the data.

Within the GWTG-R data registry, ARC events are defined by absent, agonal or inadequate respiration that requires emergency assisted ventilation, including non-invasive (e.g., mouth-to-mouth, mouth-to-barrier device, bag-valve-mask, continuous positive airway pressure or bilevel positive airway pressure) or invasive (e.g., endotracheal or tracheostomy tube, laryngeal mask airway) positive pressure ventilation. Elective intubations and events beginning outside the hospital are not included.[12]

Cohort selection

From the GWTG-R ARC database we initially identified 34,104 ARC events in adults (age ≥18) occurring between June 2005 and June 2015. Of these, we included only index cases, leading to the exclusion of 1644 non-index events. We also excluded ARC events suffered by visitors/staff (n = 41), those that occurred in the emergency department (n = 3487), those in which an invasive airway or non-invasive positive pressure ventilation was already in place (n = 5676), and those that resulted in cardiac arrest (n = 1755). An additional 467 events were excluded due to missing data on in-hospital mortality. Finally, 7841 patients had missing data on one or more candidate variables. A comparison between the group with missing data and the final study cohort can be found in Table S1 in the Supplementary materials. The final study cohort included 13,193 unique ARC events. See Fig. 1 for complete details on cohort selection.

Table 1
Patient and event characteristics.

	Derivation cohort (n = 9,807)	Validation cohort (n = 3,386)
Demographics		
Age (years)		
<50	1672 (17)	606 (18)
50–59	1822 (19)	637 (19)
60–69	2305 (24)	773 (23)
70–79	2187 (22)	728 (22)
>80	1821 (19)	642 (19)
Sex (female)	4609 (47)	1602 (47)
Illness category		
Medical cardiac	1929 (20)	661 (20)
Medical non-cardiac	5753 (59)	2023 (60)
Surgical cardiac	353 (4)	120 (4)
Surgical non-cardiac	1772 (18)	582 (17)
Pre-event conditions		
CHF this admission	1548 (16)	525 (16)
Hypotension	1759 (18)	621 (18)
Acute stroke	613 (6)	200 (6)
Acute non-stroke neurological event	1183 (12)	432 (13)
Pneumonia	1886 (19)	641 (19)
Septicemia	1607 (16)	534 (16)
Major trauma	326 (3)	114 (3)
Location of the event		
Floor without telemetry	2590 (26)	918 (27)
Floor with telemetry/step-down unit	2590 (26)	894 (26)
Intensive care unit	3800 (39)	1287 (38)
Other[a]	827 (8)	287 (8)
Event characteristics		
Monitored	7766 (79)	2641 (78)
Time of the day (night)	2864 (29)	1010 (30)
Time of week (weekend)	2150 (22)	777 (23)
Hospital wide response activated	6304 (64)	2140 (63)
Patient conscious	5032 (51)	1696 (50)
Breathing pattern		
Breathing	5448 (56)	1906 (56)
Not breathing	1623 (17)	520 (15)
Agonal	2736 (28)	960 (28)
Supplemental oxygen in place	7749 (79)	2718 (80)
Rhythm at start of event		
Bradycardia	1342 (14)	409 (12)
Sinus (including sinus tachycardia)	7316 (75)	2544 (75)
Supraventricular tachycardia	671 (7)	247 (7)
Other	478 (5)	186 (5)
Ventilation		
Endotracheal tube inserted	8609 (88)	2970 (88)
Bag-valve mask	8897 (91)	3028 (90)
CPAP/BiPAP	596 (6)	232 (7)
End of event		
Return of spontaneous ventilation	881 (9)	306 (9)
Control with assisted ventilation	8926 (91)	3080 (91)

[a] Other refers to the following locations: post-anesthesia care unit, ambulatory/outpatient area, cardiac catheterization laboratory, delivery suite, diagnostic/intervention area, operating room, rehab, skilled nursing or mental health unit/facility, and same-day surgical area.

Candidate variables and primary outcome

Candidate variables were selected on the basis of their potential as predictors of the study outcome. All variables collected in the GWTG-R ARC data registry were screened for inclusion by three clinicians and any discrepancies resolved through consensus. Included candidate variables are listed in Table 1. For definitions of