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ACUTE RESPIRATORY COMPROMISE IN THE EMERGENCY DEPARTMENT: A DESCRIPTION AND ANALYSIS OF 3571 EVENTS FROM THE GET WITH THE GUIDELINES–RESUSCITATION® REGISTRY

Carl Mathias Karlsson, BS^{*,†}, Michael W. Donnino, MD^{*,‡}, Hans Kirkegaard, MD, PHD, DSC[†], Michael N. Cocchi, MD^{*,§}, Maureen Chase, MD, MPH^{*}, and Lars W. Andersen, MD, MPH, PHD^{*,†,||} for the American Heart Association's Get With the Guidelines–Resuscitation® Investigators

^{*}Department of Emergency Medicine, Beth Israel Deaconess Medical Center, Boston, Massachusetts

[†]Research Center for Emergency Medicine, Aarhus University Hospital, Aarhus, Denmark

[‡]Department of Medicine, Division of Pulmonary, Critical Care, and Sleep Medicine, Beth Israel Deaconess Medical Center, Boston, Massachusetts

[§]Department of Anesthesia Critical Care, Division of Critical Care, Beth Israel Deaconess Medical Center, Massachusetts

^{||}Department of Anesthesiology, Aarhus University Hospital, Aarhus, Denmark

Abstract

Background—Respiratory events requiring the use of assisted ventilation are relatively common in the emergency department (ED), and can be associated with substantial morbidity and mortality.

Objective—The aim of this study was to describe and elucidate patient and event characteristics associated with mortality and progression to cardiac arrest in ED patients with acute respiratory compromise.

Methods—Data were obtained from the multi-center Get With the Guidelines–Resuscitation® registry. We included patients with acute respiratory compromise defined as absent, agonal, or inadequate respiration that required emergency assisted ventilation. All adult patients between January 2005 and December 2014 with an index event in the ED were included. We used multivariable logistic regression models to assess the association between patient and event characteristics and in-hospital mortality, with cardiac arrest during the event as a secondary outcome.

Reprint Address: Lars W. Andersen, MD, MPH, PHD, Research Center for Emergency Medicine, Aarhus University Hospital, Nørrebrogade 44, Bygning 30, 1. sal, 8000 Aarhus C, Denmark.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.jemermed.2016.11.060>.

Results—A total of 3571 events were included. The in-hospital mortality was 34%. Twelve percent of events progressed to cardiac arrest, with a subsequent 82% in-hospital mortality. When adjusting for patient and event characteristics, we found no temporal changes in in-hospital mortality from 2005 to 2014. Several characteristics were associated with increased mortality, such as pre-event hypotension, septicemia, and acute stroke. Similarly, multiple characteristics, including pre-event hypotension, were associated with progression to cardiac arrest.

Conclusions—Patient with acute respiratory compromise in the ED had an in-hospital mortality of 34% in the current study. These patients also have a high risk of progressing to cardiac arrest, with a subsequent increase in in-hospital mortality to 82%. Potentially reversible characteristics, such as hypotension before the event, showed a strong association to in-hospital mortality, along with multiple other patient and event characteristics.

Keywords

acute respiratory compromise; emergency department; outcomes; cardiac arrest; intubation

INTRODUCTION

Acute respiratory compromise events in the emergency department (ED) are relatively common, and often require the use of assisted ventilation (1). Events requiring emergency assisted ventilation, especially endotracheal intubation, in the ED have been associated with poor outcomes in a number of single-center studies (2–5). However, these studies have primarily focused on short-term outcomes, such as post-intubation hypotension or cardiac arrest, with only two of these studies evaluating mortality secondarily (2–5).

A recent study from the Get With the Guidelines–Resuscitation® (GWTG-R) registry examining patients on inpatient wards with acute respiratory compromise (i.e., an event requiring emergency assisted ventilation) found that not only are these events common, they are also associated with very high mortality (approximately 40%) (6). In addition, numerous patient and event characteristics, such as agonal breathing, hypotension, and septicemia were associated with increased in-hospital mortality. Whether these associations are similar in the ED remains unknown.

The aim of this study was to describe and elucidate patient and event characteristics associated with mortality in ED patients with acute respiratory compromise events starting in the ED. We hypothesized that potentially reversible characteristics, such as hypotension before the event, would be associated with increased mortality.

METHODS

Data Source and Definitions

Data were obtained from the GWTG-R® registry, which is a United States (US)-based quality-improvement registry funded by the American Heart Association (7). Trained personnel at each participating site collect and enter data on in-hospital acute respiratory compromise, cardiac arrest, and medical emergency team events, in accordance with

standardized definitions. Using standardized software and certification of data-entry personnel, the integrity of the data is further improved (8).

The GWTG-R registry defines acute respiratory compromise as absent, agonal, or inadequate respiration that requires emergency assisted ventilation, including noninvasive or invasive positive pressure ventilation. Only events that elicit a hospital-wide or unit-wide response are included. Events starting before ED arrival are not included.

The end of the event is defined as: return of spontaneous ventilation for > 20 min, control of ventilation through assisted ventilation for > 20 min, or progression into cardiopulmonary arrest (including interventions terminated because of advance directives). Events that follow return of spontaneous ventilation for > 20 min are considered a new acute respiratory compromise event. Similarly, if cardiac arrest occurs after sustained return of spontaneous ventilation or sustained control of ventilation through assisted ventilation (i.e., > 20 min), this cardiac arrest is not included in the current study. Definitions for all included variables are provided in the Supplementary Data (eTable 1, available online).

Cohort Selection

For this study, we included acute respiratory compromise events beginning in the ED in adults (18 years or older) between January 2005 and December 2014, although the majority of hospitals participated in the registry for much shorter periods of time. Non-index events and events occurring in staff/visitors were excluded. We further excluded patients with an invasive airway or noninvasive positive pressure ventilation in place at the beginning of the event and those with missing data on mortality (Figure 1).

The primary outcome of this study was in-hospital mortality. Secondarily, we evaluated progression to cardiac arrest during the event. This secondary outcome has previously been evaluated in an earlier GWTG-R study, including patients from all hospital locations (i.e., also including patients outside the ED) (9).

Statistical Analysis

Continuous variables are reported as medians with first and third quartiles due to non-normal distribution of data. Categorical data are reported as counts with relative frequencies.

A list of potentially relevant clinical variables was created a priori (Table 1). These variables were selected based on clinical relevance, determined by the author team and prior literature (6,9). First, the association between each variable and mortality was assessed in unadjusted logistic regression. All candidate variables were then entered into a multivariable logistic regression model with in-hospital mortality as the outcome. To account for correlations between patients within the same hospital, generalized estimation equations were used with an exchangeable variance-covariance structure. This analysis was repeated for the secondary outcome, and in a post-hoc subgroup analysis including only patients that were intubated during the event. For the primary multivariable analyses, we only included patients with no missing data on included variables (complete case analysis).

Multiple imputation was conducted as a sensitivity analysis to account for missing data on included variables. Data were complete on all covariates for 2137 patients (60%). The median number of missing covariates was 0 (quartiles: 0, 1). In order to account for this, missing values for categorical covariates were imputed using the fully conditional specification method, assuming that the data were missing at random, and a total of 10 data sets were created (10). We then performed the analyses on these 10 data sets and combined the results using SAS's proc mianalyze (SAS Institute, Cary, NC).

Results from the multivariable logistic regression models are reported as odds ratios (OR) with 95% confidence interval (CI). Hypothesis tests were two-sided, with a significance level $p < 0.05$. All statistical analysis was performed using SAS software, version 9.4 (SAS Institute).

RESULTS

Patient Characteristics

Of a total of 39,756 events in the registry, 3571 index events in ED patients were included in our study (Figure 1) from 217 hospitals. For years in which at least one case was reported, the median number of events per year per hospital was two (quartiles 1, 4). Median age was 61 years (quartiles: 48, 74) and 1602 were female (45%). The majority of patients were in the medical noncardiac illness category (71%), were monitored (91%), and received supplemental oxygen (80%) at the start of the event. Additional patient and event characteristics are provided in Table 1.

The majority of patients (90%) were intubated during the event. Additional information on interventions during the event is presented in Table 2. The most commonly used drugs were neuromuscular blockade (59%) and sedative agents (69%).

In-Hospital Mortality

In-hospital mortality in the study cohort was 34%. Patient characteristics according to mortality status are illustrated in Table 3. Temporal mortality trends are illustrated in Figure 2. Mortality decreased over time in unadjusted analysis (OR per year = 0.95; 95% CI 0.92–0.97; $p < 0.001$). This decrease remained in a post-hoc sensitivity analysis when excluding the year 2005 (OR per year = 0.96; 95% CI 0.93–0.98; $p = 0.002$). However, there was no significant temporal trend in multivariable analysis (OR per year = 1.00; 95% CI 0.97–1.04; $p = 0.86$).

Multivariable analysis showed that age, a medical cardiac admission diagnosis, inadequate breathing at the start of the event, acute stroke, and hypotension were associated with increased in-hospital mortality. Characteristics such as female sex, consciousness at the start of the event, and receipt of nebulizer treatment up to 4 h before the event, were associated with decreased in-hospital mortality. The results of the multivariable analysis for in-hospital mortality are presented in Table 4 for both the nonimputed and the imputed cohort. Results were largely similar in the two analyses.

Progression to Cardiac Arrest

Twelve percent of the acute respiratory compromise events progressed to cardiac arrest. In those with cardiac arrest, in-hospital mortality was 82% compared to 27% in those without a cardiac arrest ($p < 0.001$). Median time to cardiac arrest from the beginning of the event was 8 min (quartiles: 3, 15) (see Figure 3). This information was missing on 6% of the patients. Temporal cardiac arrest trends are illustrated in Figure 2. There was a decrease in progression to cardiac arrest during the event over time in unadjusted analysis (OR = 0.93; 95% CI 0.90–0.96; $p < 0.001$). This trend was not significant in a post-hoc sensitivity analysis when excluding the year 2005 (OR = 0.97; 95% CI 0.93–1.01; $p = 0.12$), neither was there a trend in multivariable analysis (OR = 1.03; 95% CI 0.97–1.10; $p = 0.37$).

Multivariable analysis showed that a medical cardiac diagnosis and hypotension were associated with increased odds of the event progressing to cardiac arrest. Conversely, congestive heart failure, pneumonia, acute stroke, acute nonstroke neurologic states, and consciousness at the start of the event were associated with decreased odds of progression to cardiac arrest. The results of the multivariable analysis for cardiac arrest for both the nonimputed and the imputed cohort are presented in Table 5. Results were largely similar in the two analyses.

Subgroup Analysis: Intubated Patients

Three thousand two hundred and eighteen patients were intubated during the event. Mortality for the intubated population was 35%, and 11% of these events progressed into a cardiac arrest. Mortality in the patients suffering a cardiac arrest in this subgroup was 82%, and 29% in those not suffering a cardiac arrest ($p < 0.001$). The results in this subgroup (eTables 2 and 3) were very similar to our main analysis (Tables 4 and 5). A medical cardiac illness category, hypotension before the event, acute stroke, septicemia, and inadequate breathing were associated with increased in-hospital mortality. Receiving nebulizers within 4 h before the event and consciousness at the start of the event were associated with decreased mortality.

Age, a medical cardiac illness category, and hypotension were associated with increased odds of developing a cardiac arrest during the event, while a pre-existing condition of stroke or a nonstroke neurologic event and consciousness at the start of the event were associated with decreased odds of progression to cardiac arrest.

DISCUSSION

In this study, we found that in-hospital mortality after an acute respiratory compromise event in the ED was as high as 34%. Twelve percent of the events progressed into cardiac arrest and in-hospital mortality for those patients was 82%. We identified several patient and event characteristics associated with increased in-hospital mortality and progression to cardiac arrest during the event. Among these factors, pre-event hypotension was related to both in-hospital mortality and progression to cardiac arrest, confirming our hypothesis.

The current literature on acute respiratory compromise events in the ED is scarce and, to our knowledge, there are only smaller single-center studies evaluating in-hospital mortality in

this patient population. Heffner et al. published several papers on the complications of emergency intubation in the ED (2,3). They found that post-intubation hypotension was not only a prevalent condition in this population, but also independently associated with mortality (2,3). They also found that 4.2% of patients with emergency airway management experience cardiac arrest, lower than the cardiac arrest prevalence of 12% reported in this study (4). They also report an overall mortality of 24%, also lower than the 37% we found in our study cohort. These disparities can likely be explained by discrepancies in definitions and patient characteristics as well as potential selection bias in the current study. We used the GWTG-R acute respiratory compromise definition that includes the use of assisted emergent ventilation and a hospital- or unit-wide response. Furthermore, the reported mean age in their study was 49 years, much lower than the median age of 61 years reported in this study. As such, it is likely that the current study includes an older and sicker patient population, which explains, at least in part, the difference in outcomes. In addition, Heffner et al. did not exclude patients who had their onset of respiratory symptoms before ED arrival, although they did exclude patients intubated before ED arrival. This might further explain some of the disparities in our findings.

Kim et al. found a post-intubation cardiac arrest prevalence of 1.7% in the ED for arrests that occurred within 10 min of intubation (5). Similar to Heffner et al., the lower estimate from their study may be attributed to the difference in definitions discussed previously, as well as the short window for cardiac arrest events to occur (2–4). Kim et al. found that systolic hypotension (defined as mean arterial pressure < 90 mm Hg, measured directly before intubation) was independently associated with post-intubation cardiac arrest, consistent with the findings reported here. In an earlier study from the GWTG-R registry using data from 2004 to 2006, Wang et al. evaluated the incidence of events progressing to cardiac arrest in the entire hospital population with acute respiratory compromise and found an overall mortality of 49% with 17% of the events ending in cardiac arrest (9). Considering that their patient population incorporated locations such as the intensive care unit, with an innate higher morbidity and mortality, this higher reported mortality and post-intubation cardiac arrest is expected. Consistent with this study they also found that hypotension is associated with increased risk of developing cardiac arrest during an acute respiratory compromise event (9).

We identified several event characteristics associated with mortality and progressing to cardiac arrest. Some of these characteristics, such as hypotension, are potentially modifiable. There have been preliminary attempts at uncovering whether complications can be reduced by treating hypotension during the intubation period. Panchal et al. retrospectively evaluated the use of bolus-dose phenylephrine in ED patients and found that patients given a bolus dose of phenylephrine in the peri-intubation period had higher systolic and diastolic blood pressure than those who did not (11). However, they were not able to evaluate the effect on mortality or other relevant outcomes due to confounding factors and a small sample size (11). Jaber et al. attempted to address whether intubation-related hypotension, and other intubation-related complications could be reduced in a before-and-after interventional trial (12). In the intensive care unit setting, they compared patients receiving standard of care with patients receiving an implemented care bundle (including among other things preintubation fluid loading). They found that patients in the intervention group had

significantly lower incidence of moderate and life-threatening complications. However, they found no difference between the groups in intensive care unit length of stay or in in-hospital mortality (12). An important goal of future research is to determine whether correction of pre-event hypotension could lead to improved post-event outcomes.

The findings in this study that septicemia and hypotension were associated with an increased risk of progression to cardiac arrest during the event are not surprising, and can likely be explained by underlying hemodynamic instability (6). As such, the findings that congestive heart failure, acute stroke, and acute nonstroke neurologic events are seemingly protective with regard to developing a cardiac arrest could be interpreted in the same context. Patients with stroke and congestive heart failure tend to present in a more hemodynamically stable state with either normo- or hypertension (13,14). This could provide a possible explanation as to why these patients suffer a cardiac arrest during the event less frequently. However, stroke was still associated with in-hospital mortality, potentially as a consequence of neurologic, as contrasted with hemodynamic, decompensation later in the hospital course. As such, future ED studies could focus on optimizing hemodynamics before assisted ventilation in this high-risk patient population. Nebulized treatments up to 4 h before the event were associated with decreased in-hospital mortality. It is likely that those in the group receiving this therapy have different underlying conditions, such as asthma and chronic obstructive pulmonary disease, which could explain the lower in-hospital mortality in this group.

Limitations

The findings of this study should be interpreted in the context of the study design. Although the American Heart Association encourages reporting of all cases, personnel at participating sites entered data into the registry on a voluntary basis and reporting bias might therefore exist. As such, it remains a possibility that more severe cases have a higher likelihood of being reported. Thus, the inhospital mortality and cardiac arrest incidence reported in this study could be overestimated. It is important to note that although we find many potentially important associations, these associations do not necessarily imply causation. Furthermore, the variables used in this study are based on previous literature, availability in the data set, and author group consensus. As such, some important variables might not have been included in this study. With these limitations in mind, the generalizability of our findings might be limited and external validity would need to be evaluated in future studies. Furthermore, missing data within the database are an issue. While missing data on single variables are not negligible, the total amount of missing data is very low (median: 0 missing variables [quartiles 0, 1]). We attempted to account for this with multiple imputation techniques, which showed relatively similar results compared to our main analysis. Lastly, important data, such as the precise etiology of the event and information on the etiology of death, are not available in this data set.

CONCLUSIONS

We found that in-hospital mortality in a large multicenter sample of ED patients with acute respiratory compromise events was 34% and 12% developed a cardiac arrest during the

event. We found several event characteristics associated with in-hospital mortality and progression to cardiac arrest, including pre-event hypotension. Given the high mortality of this patient population, acute respiratory compromise should be a future research priority.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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ARTICLE SUMMARY

1. Why is this topic important?

Patients suffering acute respiratory compromise events in the emergency department are a common occurrence and few multicenter studies have identified risk factors associated with outcomes.

2. What does this study attempt to show?

Outcomes for patients with acute respiratory compromise are poor, and important and potentially modifiable risk factors can be identified.

3. What are the key findings?

Outcomes are poor for patients with acute respiratory compromise in the emergency department. Important risk factors, such as hypotension and septicemia, are associated with increased risk of progression to cardiac arrest and with in-hospital mortality.

4. How is patient care impacted?

This study may increase clinical focus on an important but understudied clinical entity and help clinicians identify high-risk patients. Describing the patient population and identifying risk factors could lay the ground for additional interventional studies to improve outcomes for this clinical event.

Figure 1.

Inclusion/exclusion flow diagram. There were 39,756 adult acute respiratory compromise (ARC) events identified in the Get With the Guidelines–Resuscitation® database. We excluded events not in the emergency department ($n = 35,473$), non-index events ($n = 65$), patients with an invasive airway or assisted ventilation already in place ($n = 629$), and events in visitors/staff ($n = 4$). The final study cohort consisted of 3571 acute respiratory compromise events. Acute respiratory compromise is defined as absent, agonal, or inadequate respiration that requires emergency assisted ventilation, including noninvasive (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.

Figure 2.

Temporal trends in mortality and cardiac arrest. Trends over time for in-hospital mortality and progression to cardiac arrest. There was a significant decrease in inhospital mortality over time in unadjusted analysis (odds ratio [OR] = 0.95; 95% confidence interval [CI] 0.92–0.97; $p < 0.001$), but this trend did not remain in multivariable analysis (OR = 0.99; 95% CI 0.95–1.03; $p = 0.86$). There was a significant decrease in the proportion of events progressing to cardiac arrest over time in univariate analysis (OR = 0.93; 95% CI 0.89–0.96; $p < 0.001$). This trend was not significant in multivariable analysis (OR = 1.03; 95% CI 0.96–1.10; $p = 0.40$). Reported as in-hospital mortality (black circles) and event cardiac arrest (gray squares) with 95% exact binomial confidence intervals.

Figure 3.

Time to cardiac arrest. Time to cardiac arrest in minutes from the beginning of the event until cardiac arrest in those that progressed into a cardiac arrest. Median time to cardiac arrest from the beginning of the event was 8 min (quartiles: 3, 15). Eight percent of the patients with a cardiac arrest had a time to the cardiac arrest of > 30 min and these are not included in the figure for illustrative purposes.

Table 1

Patient and Event Characteristics

Variable	Nonimputed Cohort (n = 3571)		
	Values	Missing	Imputed Cohort(n = 3571)
Demographics			
Age, y, median (quartiles)	61 (48, 74)	0 (0)	61 (48, 74)
Sex (female)	1602 (45)	1 (0)	1603 (45)
Race		313 (9)	
White	1985 (61)		2166 (61)
Black	1153 (35)		1274 (36)
Other	120 (4)		131 (4)
Illness category			
Medical cardiac	69 (19)	5 (0)	671 (19)
Medical noncardiac	2515 (71)		2518 (71)
Surgical	82 (2)		82 (2)
Trauma	300 (8)		300 (8)
Pre-existing conditions			
CHF this admission	348 (12)	639 (18)	412 (12)
Hypotension	535 (18)		640 (18)
Acute stroke	260 (9)		318 (9)
Acute nonstroke neurologic event	773 (26)		951 (27)
Pneumonia	452 (15)		558 (16)
Septicemia	320 (11)		392 (11)
Major trauma	298 (10)		312 (9)
None of the above	702 (24)		889 (25)
Event characteristics			
Monitored	3232 (91)	0 (0)	3232 (91)
Nebulizer within 4 h before event	281 (8)	0 (0)	281 (8)
Hospital-wide response activated	554 (16)	0 (0)	554 (16)
Patient conscious	1703 (52)	286 (8)	1852 (52)
Breathing pattern *		261 (7)	
Breathing	2341 (71)		2506 (70)
Not breathing	351 (11)		386 (11)
Agonal	618 (19)		679 (19)
Supplemental oxygen in place	2619 (80)	290 (8)	2843 (80)
Time of event			
Daytime (07:00 AM–11:00 PM)	2415 (74)	301 (8)	2634 (74)
Weekend	1006 (28)	0 (0)	1006 (28)
Year of event			
2005–2006	531 (15)	0 (0)	531 (15)
2007–2008	774 (22)		774 (22)
2009–2010	716 (20)		716 (20)

Variable	<u>Nonimputed Cohort (n = 3571)</u>		Imputed Cohort(n = 3571)
	Values	Missing	
2011–2012	608 (17)		608 (17)
2013–2014	942 (26)		942 (26)

CHF = congestive heart failure.

Values are n (%) unless otherwise noted.

* Breathing pattern when need for emergency assisted ventilation was first identified.

Table 2**Resuscitation Interventions**

Intervention	n (%)
Type of ventilation *	
Bag-valve mask	2712 (76)
Endotracheal tube	3218 (90)
CPAP/BiPAP	313 (9)
Mouth-to-mouth or barrier device	11 (0)
Tracheostomy	14 (0)
Laryngeal mask	7 (0)
Other noninvasive ventilation	48 (1)
Drugs given	
Bronchodilator	53 (1)
Sodium bicarbonate	116 (3)
Calcium chloride/gluconate	66 (2)
Dextrose	63 (2)
IV fluid bolus	771 (22)
Reversal agent	222 (6)
Magnesium sulfate	55 (2)
Prostaglandins	3 (0)
Neuromuscular blockade	2106 (59)
Reversal agent	224 (6)
Sedation/Induction	2463 (69)
Other	715 (20)
None	464 (13)

BiPAP = biphasic positive airway pressure; CPAP = continuous positive airway pressure.

* Missing data on 3 (0%) events.

Table 3

Patient and Event Characteristics in Survivors and Nonsurvivors in the Nonimputed Cohort

Variable	Survivors (n = 2370)	Nonsurvivors (n = 1201)	OR (95% CI)	p Value
Demographics				
Age, y, median (quartiles)	58 (45, 71)	68 (54, 80)	1.03* (1.02–1.03)	< 0.001
Sex (female)	1056 (45)	546 (46)	1.03 (0.90–1.19)	0.61
Race				
White	1262 (59)	723 (64)	Reference	Reference
Black	800 (38)	353 (31)	0.77 (0.66–0.90)	0.001
Other	70 (3)	50 (4)	1.25 (0.86–1.81)	0.25
Illness category				
Medical cardiac	380 (16)	289 (24)	1.66 (1.39–1.97)	< 0.001
Medical noncardiac	1724 (73)	791 (66)	Reference	Reference
Surgical	43 (2)	39 (3)	1.98 (1.27–3.07)	0.003
Trauma	220 (9)	80 (7)	0.79 (0.61–1.04)	0.09
Pre-existing conditions				
CHF this admission	245 (13)	103 (10)	0.81 (0.63–1.03)	0.09
Hypotension	223 (11)	312 (32)	3.58 (2.95–4.34)	< 0.001
Acute stroke	140 (7)	120 (12)	1.79 (1.38–2.31)	< 0.001
Acute nonstroke neurologic event	549 (28)	224 (23)	0.75 (0.63–0.89)	0.002
Pneumonia	306 (16)	146 (15)	0.93 (0.75–1.15)	0.52
Septicemia	155 (8)	165 (17)	2.32 (1.84–2.94)	< 0.001
Major trauma	215 (11)	83 (8)	0.74 (0.57–0.97)	0.03
None of the above	510 (26)	192 (19)	0.68 (0.57–0.82)	< 0.001
Event characteristics				
Monitored	2125 (90)	1107 (92)	1.36 (1.06–1.74)	0.02
Nebulizer within 4 h before event	223 (9)	58 (5)	0.49 (0.36–0.66)	< 0.001
Hospital-wide response activated	364 (15)	190 (16)	1.04 (0.86–1.25)	0.72
Patient conscious	1235 (56)	468 (43)	0.58 (0.50–0.67)	< 0.001
Breathing pattern [†]				
Breathing	1727 (78)	614 (57)	Reference	Reference
Not breathing	191 (9)	160 (15)	2.36 (1.87–2.96)	< 0.001
Agonal	307 (14)	311 (29)	2.85 (2.37–3.42)	< 0.001
Supplemental oxygen in place	1742 (80)	877 (80)	1.00 (0.83–1.20)	0.98
Time of event				
Night time (11:00 PM–07:00 AM)	581 (27)	276 (25)	0.90 (0.77–1.07)	0.26
Weekend	685 (29)	321 (27)	0.90 (0.77–1.05)	0.17

CHF = congestive heart failure; CI = confidence interval; OR = odds ratio. Values are n (%) unless otherwise noted.

* Per year increase in age.

[†] Breathing pattern when need for emergency assisted ventilation was first identified.

Table 4**Multivariable Model for In-Hospital Mortality**

Variable	Nonimputed Cohort (n = 2137)		Imputed Cohort (n = 3571)	
	OR (95% CI)	p Value	OR (95% CI)	p Value
Demographics				
Age	1.02* (1.01–1.03)	< 0.001	1.02* (1.02–1.03)	< 0.001
Sex (female)	0.80 (0.68–0.94)	0.006	0.87 (0.75–0.99)	0.05
Race				
White	Reference	Reference	Reference	Reference
Black	1.12 (0.84–1.49)	0.45	1.01 (0.82–1.25)	0.89
Other	1.63 (1.15–2.32)	0.006	1.55 (1.18–2.03)	0.002
Illness category				
Medical cardiac	1.57 (1.15–2.15)	0.005	1.39 (1.05–1.83)	0.02
Medical noncardiac	Reference	Reference	Reference	Reference
Surgical	1.85 (0.94–3.61)	0.07	1.66 (0.99–2.78)	0.05
Trauma	0.93 (0.52–1.64)	0.79	1.48 (0.88–2.48)	0.14
Pre-existing conditions				
CHF this admission	0.76 (0.54–1.08)	0.13	0.68 (0.50–0.91)	0.009
Hypotension	2.72 (2.11–3.51)	< 0.001	2.69 (2.11–3.44)	< 0.001
Acute stroke	2.13 (1.36–3.34)	0.001	2.21 (1.49–3.27)	< 0.001
Acute nonstroke neurologic event	0.90 (0.63–1.28)	0.55	0.85 (0.65–1.13)	0.27
Pneumonia	0.95 (0.70–1.30)	0.75	0.83 (0.67–1.04)	0.10
Septicemia	1.92 (1.33–2.77)	< 0.001	1.98 (1.42–2.77)	< 0.001
Major trauma	1.52 (0.90–2.57)	0.12	0.93 (0.55–1.55)	0.77
None of the above	0.97 (0.73–1.29)	0.84	0.92 (0.72–1.18)	0.52
Event characteristics				
Monitored	1.46 (0.97–2.18)	0.07	1.47 (1.12–1.92)	0.005
Nebulizer within 4 h before event	0.64 (0.46–0.87)	0.004	0.80 (0.62–1.03)	0.08
Hospital-wide response activated	0.74 (0.55–1.01)	0.06	0.76 (0.61–0.96)	0.02
Patient conscious	0.78 (0.65–0.95)	0.01	0.74 (0.62–0.88)	< 0.001
Breathing pattern [†]				
Breathing	Reference	Reference	Reference	Reference
Not breathing	1.69 (1.18–2.42)	0.004	1.84 (1.37–2.47)	< 0.001
Agonal	1.94 (1.47–2.58)	< 0.001	1.79 (1.38–2.33)	< 0.001
Supplemental oxygen in place	1.41 (1.05–1.90)	0.02	1.31 (1.04–1.66)	0.02
Time of event				
Night time (11:00 PM–07:00 AM)	1.03 (0.84–1.26)	0.77	0.97 (0.83–1.14)	0.75
Weekend	0.86 (0.71–1.04)	0.13	0.86 (0.74–1.00)	0.04
Year of the event	1.00 (0.97–1.04)	0.86	0.99 (0.95–1.03)	0.61

CHF = congestive heart failure; CI = confidence interval; OR = odds ratio.

* Per year increase in age.

[†]Breathing pattern when need for emergency assisted ventilation was first identified.

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Table 5**Multivariable Model for Event Progressing to Cardiac Arrest**

Variable	Nonimputed Cohort (n = 2143)		Imputed Cohort (n = 3585)	
	OR (95% CI)	p Value	OR (95% CI)	p Value
Demographics				
Age	1.01 [*] (1.00–1.01)	0.08	1.01 (1.00–1.01)	0.001
Sex (female)	1.04 (0.89–1.22)	0.59	1.04 (0.92–1.17)	0.53
Race				
White	Reference	Reference	Reference	Reference
Black	0.87 (0.68–1.11)	0.26	0.91 (0.76–1.10)	0.34
Other	0.99 (0.60–1.61)	0.96	1.08 (0.73–1.60)	0.69
Illness category				
Medical cardiac	2.04 (1.43–2.93)	< 0.001	2.11 (1.54–2.89)	< 0.001
Medical noncardiac	Reference	Reference	Reference	Reference
Surgical	1.29 (0.73–2.27)	0.38	1.07 (0.68–1.67)	0.78
Trauma	0.89 (0.54–1.45)	0.63	0.97 (0.66–1.42)	0.86
Pre-existing conditions				
CHF this admission	0.66 (0.48–0.91)	0.01	0.59 (0.43–0.82)	0.002
Hypotension	1.84 (1.38–2.46)	< 0.001	1.60 (1.27–2.01)	< 0.001
Acute stroke	0.39 (0.26–0.60)	< 0.001	0.42 (0.28–0.65)	< 0.001
Acute nonstroke neurologic event	0.72 (0.55–0.95)	0.02	0.75 (0.59–0.96)	0.02
Pneumonia	0.73 (0.54–0.99)	0.04	0.71 (0.56–0.90)	0.004
Septicemia	0.72 (0.49–1.06)	0.10	0.82 (0.64–1.06)	0.14
Major trauma	0.99 (0.60–1.63)	0.96	1.00 (0.68–1.48)	0.98
None of the above	0.97 (0.72–1.32)	0.86	0.95 (0.70–1.28)	0.71
Event characteristics				
Monitored	1.56 (1.04–2.33)	0.03	1.47 (1.09–1.99)	0.01
Nebulizer within 4 h before event	1.32 (0.90–1.92)	0.15	1.13 (0.87–1.46)	0.36
Hospital-wide response activated	0.83 (0.56–1.25)	0.38	0.95 (0.74–1.23)	0.70
Patient conscious	0.76 (0.63–0.92)	0.005	0.84 (0.71–1.00)	0.06
Breathing pattern [†]				
Breathing	Reference	Reference	Reference	Reference
Not breathing	1.50 (0.99–2.28)	0.06	2.00 (1.42–2.81)	< 0.001
Agonal	2.18 (1.59–2.98)	< 0.001	2.11 (1.64–2.71)	< 0.001
Supplemental oxygen in place	1.05 (0.77–1.45)	0.74	1.06 (0.83–1.35)	0.65
Time of event				
Night time (11:00 PM–07:00 AM)	1.08 (0.88–1.32)	0.46	1.21 (1.03–1.43)	0.02
Weekend	1.11 (0.91–1.36)	0.30	1.07 (0.93–1.24)	0.33
Year of the event	1.03 (0.97–1.10)	0.37	1.03 (0.98–1.08)	0.25

CHF = congestive heart failure; CI = confidence interval; OR = odds ratio.

^{*} Per year increase in age.

[†]Breathing pattern when need for emergency assisted ventilation was first identified.

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