**INITIAL ARTERIAL PH AS A PREDICTOR OF NEUROLOGIC OUTCOME AFTER OUT-OF-
HOSPITAL CARDIAC ARREST: A PROPENSITY-ADJUSTED ANALYSIS**

by

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Table of Contents

List of Tables	4
List of Figures	5
Acknowledgements	6
Abstract	8
Introduction	10
Methodology	13
Results	17
Discussion	21
Limitations	25
Future Directions	26
Conclusions	27
Tables	28
Figures	32
References	43

List of Tables

Table 1. Baseline Characteristics Stratified by Neurologic Outcome	28
Table 2. Neurologic Outcomes and Odds Ratios by pH Thresholds	29
Table 3. Covariate Balance Pre- and Post-Adjustment	30
Table 4. Sample Size of Unweighted Versus Weighted Controls	31

List of Figures

Figure 1. Cerebral Performance Category Definitions	32
Figure 2. Distribution of Initial Post-ROSC Arterial pH by Neurologic Outcome	33
Figure 3. Density Plots of the Raw Propensity Score by pH Thresholds	34
Figure 4. Love Plot of Covariate Balance by pH Thresholds	38
Figure 5. Pre- and Post-Adjustment Odds Ratios by pH Thresholds	42

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Initial Arterial pH as a Predictor of Neurologic Outcome After Out-of-hospital Cardiac
Arrest: a Propensity-Adjusted Analysis

Abstract

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Although consensus algorithms characterize $\text{pH} < 7.2$ as an unfavorable prognostic feature after out-of-hospital cardiac arrest (OHCA), the relationship between post-arrest pH and neurologic outcomes has been poorly described. To assess this, the association between initial arterial pH after return of spontaneous circulation (ROSC) and neurologic outcome at hospital discharge was analyzed in decremental thresholds for 723 consecutive OHCA patients treated with targeted temperature management from 2008-17. After ATT-weighting on the inverse propensity score and direct adjustment for the linear propensity score, no increased hazard was observed until $\text{pH} \leq 7.1$. Utilizing thresholds of 7.15-7.3, odds ratios for poor neurologic outcome consistently ranged 1.9-2.1, but at ≤ 7.1 increased to 2.4 (95% CI 1.4-4.1), at ≤ 7.05 3.1 (95% CI 1.5-6.3), and at ≤ 7.0 4.5 (1.8-12). In conclusion, in OHCA, after adjustment for

confounding, the initial post-ROSC pH only becomes a reliable prognosticator for poor neurologic outcomes ≤ 7.1 , a lower threshold than in practice guidelines.

Introduction

The American Heart Association estimates that 347,000 adults in the United States suffer out-of-hospital cardiac arrest (OHCA) annually. Reported survival rates at hospital discharge average 10%, but only 8% of patients survive with favorable neurologic outcome, defined by cerebral performance category (CPC) <3 out of 5.(1) While cerebral anoxia remains the leading cause of morbidity and mortality in OHCA (2), neurologic outcomes have improved with the widespread integration of targeted temperature management (TTM) as standard of care for all comatose patients post-OHCA. The American Heart Association currently recommends TTM for 24 hours at 32-36°C regardless of arrest rhythm (3), a guideline supported by landmark randomized control trial(4-6) and meta-analysis (7-9) data.

In OHCA patients treated with TTM, the current consensus recommendation is to delay neurologic prognostication for >72 hours post-arrest (3, 10), a timeline consistent with a prior reported average awakening time of 3.2 days post-arrest (11). Nevertheless, the overwhelming majority of patients will not survive with meaningful neurologic function. Though the implications of premature withdrawal of care are literally life-changing, protracted and ultimately-futile hospitalizations also carry considerable emotional and financial costs for both patients and their loved ones (12, 13).

As such, multiple validated prediction models (C-GRaPH (14), CAHP (15), TTM risk score (16)) have recently been published in an effort to provide earlier neurologic outcome

stratification. Each of these scoring systems includes initial arterial pH as a predictor variable with significant weight, with lower (more acidic) pH associated with poorer neurologic outcomes. However, the relationship between initial arterial pH and neurologic outcomes is poorly characterized to date. It is not currently understood if decrements in pH are associated with incrementally worse outcomes or if a threshold pH exists, below which outcomes progressively worsen.

Based largely on nephrology and sepsis-centric literature (17, 18), pH <7.2 has historically been categorized as severe acidosis. In a current consensus care algorithm, a pH threshold of <7.2 has been identified as an “unfavorable resuscitation feature” post-OHCA, and is used as justification to forego coronary angiography, currently a class I indication with or without ST-segment elevation on ECG (19). However, the evidence supporting a 7.2 pH threshold is unclear. Though the referenced treatment algorithm cites pH data from the PROCAT registry (20), in the TTM risk score and C-GRaPH prediction models, lower pH thresholds down to <6.9 and <7.0 respectively were utilized. In fact, the applied 7.2 pH threshold has previously been evaluated in cardiac arrest (21-23), albeit in more heterogeneous populations (in- and out-of-hospital) with initial pH collected at different resuscitation points (peri-cardiopulmonary resuscitation [CPR], post-return of spontaneous circulation [ROSC]). The prior study findings are conflicting, two showing no significant worsening of neurologic outcomes (21, 23), one showing improved neurologic outcomes (odds ratio [OR] 3.3, 95% CI 1.3-8.5, $p = 0.01$) only for shockable rhythms of arrest (22).

In this large, multi-center observational study spanning a decade of OHCA patients treated with TTM, we utilized propensity weighting to adjust for confounding patient demographics/history, arrest characteristics, and post-arrest laboratory data to better characterize the prognostic association of initial arterial pH following OHCA.

Methodology

Study Population

Consecutive adult patients who were treated with TTM following OHCA with successful ROSC at the University of Virginia from 2008-2014 and the Cleveland Clinic Foundation from 2012-2017 were prospectively included in institutional registries intended for quality improvement. Institutional review board approval at both sites was then obtained for retrospective analysis of these registries. An informed consent waiver was granted.

Patients were included in this study population whether ROSC was obtained pre- or in-hospital and whether they initially presented to or were subsequently transferred to the study sites. The TTM goal was 32-34° C for 24 hours via either external or intravascular cooling techniques. Patients were not excluded from analysis if goal temperature or duration was not achieved (intention-to-treat).

Outcome Variable

The outcome variable of interest was favorable neurologic outcome at hospital discharge. As widely applied in prior landmark studies (4-6), neurologic outcome was dichotomized based on CPC score: 1-2 favorable, 3-5 poor. Full definitions of each CPC score are shown in **Figure 1**. There was logistical variability in CPC scoring between the study sites. At the University of Virginia, CPC scores were assigned retrospectively based on chart review by a consensus of neurologists who were blinded to the study question.

At the Cleveland Clinic Foundation, CPC scores were assigned by neurologists participating in the patients' care during the post-arrest hospitalization.

Exposure Variable

The exposure variable was the initial post-ROSC arterial pH. To standardize the approach and restrict to the early post-resuscitation period, arterial pH levels were included only if they were measured in the first 2 hours after ROSC. Results were obtained pre-hospital by emergency medical services (EMS) in some cases, in others by a transferring hospital, or by the study site. If multiple arterial pH values satisfied the post-ROSC time constraint, the initial value was recorded. Neither central venous pH nor peri-resuscitation (pre-ROSC) arterial pH were deemed adequate surrogates for post-ROSC arterial pH and were not included.

Covariates of Interest

Any clinical information that could reasonably be expected to be available at the time of initial arterial pH level that also exhibited either a clinical or statistical relationship with neurologic outcome and arterial pH were included as potential covariates for later adjustment. This included patient demographics, pre-arrest medical history, arrest characteristics, and other readily-available laboratory studies within 2 hours post-ROSC. This covariate data was obtained via review of available EMS and transferring hospital records, as well as via thorough electronic medical record review at the study sites. Of note, pre-arrest diagnoses were required to be known prior to the index OHCA event.

For example, if OHCA occurred in the setting of an acute myocardial infarction as the first presentation of coronary artery disease (CAD), this was not considered pre-arrest CAD.

Statistical Analysis

Continuous variables are presented as mean (standard deviation) and were compared with Student's t-test. Categorical variables are presented as number (percentage) and were compared using Pearson's chi-squared test. By rule, missing data was not present for either the exposure (initial post-ROSC arterial pH) or the outcome (favorable neurologic outcome at hospital discharge) variables. For all other baseline variables where missingness was present, simple random imputation was performed. Selection of confounding covariates for modeling was performed entirely *a priori* based on prior literature associating the included variables with neurologic outcome after OHCA. The exposure pH variable was created using a series of recursive pH thresholds with 0.05 decrements from 7.3 down to 7.0. At each pH threshold, propensity scores were created from the covariates of interest, as well as covariate-specific missingness variables present for all covariates with >10% missing data. A double robust propensity weighting strategy was selected as it demonstrated more effective balance than alternative propensity approaches. This approach utilized average treatment effect in the treated population (ATT)-weighting on the inverse propensity score and direct adjustment for the linear propensity score in the final logistic regression outcome models. Odds ratios for poor neurologic outcome were then estimated pre- and post-propensity adjustment

for each decremental pH threshold. All comparisons involved two-tailed tests at a 5% significance level. The data was analyzed using R version 3.3.2 statistical software (R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>).

Results

From 2008-2017, a total of 723 patients met inclusion criteria, 540 from the Cleveland Clinic Foundation and 183 from the University of Virginia. Overall, 226 (31%) survived to hospital discharge, but only 141 (20%) with favorable neurologic outcome. For non-survivors, median time from ROSC to death was 92 hours (IQR 53-161). Of the 497 patients dying during their index post-OHCA hospitalization, 406 (62%) survived <72 hours post-ROSC. However, roughly half of the 191 patients dying <72 hours post ROSC either re-arrested without ROSC, met clinical criteria for brain death, or had high-risk findings for severe anoxic brain injury on computed tomography (CT). Only in the remaining half (19%) did withdrawal of care occur prior to current guidelines, by directive of patients' medical power of attorney.

Baseline patient demographics, pre-arrest medical history, arrest characteristics, and initial laboratory studies are summarized in **Table 1**, stratified by neurologic outcome. In totality, nearly all univariable analyses were strongly significant ($p < 0.05$). Patients suffering poor post-OHCA neurologic outcomes were older and disproportionately likely to be female, however were still by majority male and <65 years old. Unsurprisingly, patients with pre-existing coronary artery disease (CAD), congestive heart failure (CHF), or diabetes mellitus (considered a cardiovascular disease risk equivalent) experienced worse outcomes. Nevertheless, nearly half of study patients ($n=307$, 42%) were not known to have any such cardiovascular disease pre-arrest, yet 72% went on to have poor outcomes. The majority of study patients suffered witnessed arrests. Bystander

CPR, shockable rhythm (likely ventricular fibrillation/tachycardia [VT/VF]), and shorter time to ROSC were identified as favorable resuscitation features, consistent with prior work (10). Time to ROSC was not reliably known, however, in 36% (n=257) of study patients. As for initial post-ROSC laboratory values, higher blood glucose and lactic acid and lower arterial pH were associated with worse neurologic outcomes.

The distribution of initial post-ROSC arterial pH stratified by neurologic outcome is shown in **Figure 2**. Prior to stratification or adjustment, pH, as a continuous variable, was strongly associated with neurologic outcome ($p \leq 0.001$) with a C-statistic of 0.68 but a poor Nagelkerke R^2 of 0.125. The outcomes associated with 0.05 iterative reductions in initial post-ROSC arterial pH from 7.3 to 7.0 are shown in **Table 2**. In general, favorable neurologic outcome rates steadily decrease, and thus odds ratios for poor neurologic outcome steadily increase, until a threshold of 7.10, below which this pattern is amplified.

At baseline, many covariates of interest were poorly balanced at all applied pH cutoffs. A propensity score was created for each iterative pH threshold from 7.3 to 7.0. The respective density plots are displayed in **Figure 3**. Next, Rubin's balance criteria (24) were examined pre-adjustment below and above each pH level: 1) the absolute value of the standardized differences of the logit of the propensity score, with a maximum allowable threshold <50%, ideally <10%; 2) the observed ratio of variances of the linear propensity score, required range 0.5-2.0, optimally 0.8-1.25. A summary of these

calculations are provided at each iterative pH threshold in **Table 3**. Rubin's 1st balance criteria was violated at all pH cutoffs, the 2nd at the 7.30 cutoff. As such, propensity adjustment was deemed necessary to adjust for confounding covariates in the absence of randomization.

Propensity score weighting was used to adjust for covariate imbalance, with weights established to create average treatment effect on the treated estimates. To account for additional potential sources of bias, we also included the linear propensity score in our propensity-weighted logistic regression models for outcomes.

Following propensity adjustment, the number of treatment patients (below pH threshold) versus weighted control patients (above pH threshold) at each pH cutoff are displayed in **Table 4**. The sample size of the weighted controls ranges from 24-37% the size of the unweighted controls. Given the primary issue with covariate balance prior to propensity adjustment was in the absolute value of the standardized differences, their values post-ATT-weighting for the individual covariates at each pH threshold are shown in Love plots in **Figure 4**. Following ATT-weighting and direct adjustment for the linear propensity score, Rubin's balance criteria post-adjustment can again be found in **Table 3**. At all pH thresholds, covariate balance is markedly improved and nearly meets ideal goals at all thresholds.

After both ATT-weighting and direct regression adjustment for the linear propensity score, the odds ratios for the iterative pH cutoffs were re-calculated and are displayed again in **Table 2**. Similar to the unadjusted odds ratios, a significant increase in poor neurologic outcomes was not observed until $\text{pH} \leq 7.10$, but even more markedly ≤ 7.05 and lower. Additionally, after controlling for confounding variables, the amplitude of the odds ratios at each pH threshold was decreased, at times as significantly as 50%. A graph simultaneously depicting the unadjusted and adjusted odds ratios at each applied pH cutoff is shown in **Figure 5**.

Discussion

In this large, multi-center study spanning a decade of consecutive OHCA patients treated with TTM, we demonstrate that decrements in initial post-resuscitation arterial pH are only associated with progressively poor neurologic outcomes at values ≤ 7.10 . This is a lower threshold than currently advocated for as an “unfavorable resuscitation feature” in consensus post-arrest treatment algorithms (19).

Our study has several strengths. Prior work on post-arrest pH has not controlled as rigorously for confounding covariates. Mechanistically, pH is not a criteria whose confounders can be readily randomized, and as such, propensity adjustment is likely the best alternative approach. Such an attempt has not been published previously. This study population is large, diverse, and externally generalizable. It includes patients presenting initially to medical centers in rural, suburban, and urban environments of non-academic and academic classification with post-arrest care occurring in all subtypes of intensive care units. All rhythms of arrest were represented, with TTM administered in all patients, whether via external or intravascular approach.

Our primary findings are within the range of previously-reported work on post-arrest pH and neurologic outcomes, however prior studies have yielded variable results, likely due to variability in the type, setting, and timing of the initial pH samples. In one of the largest such studies (25), Shin et al analyzed the first peri-CPR pH obtained from either an arterial or venous blood gas in >2,000 patients presenting with OHCA. The mean pH

in patients with poor neurologic outcome was 6.96 versus 7.11 with favorable neurologic outcomes ($p<0.001$). No patients with $pH<6.8$ survived with favorable neurologic outcome. However, overall outcomes were disproportionately poor (4% favorable) and only 16% received TTM. In a similar (26) but smaller emergency department (ED) study ($n=135$) of the first arterial pH drawn (whether obtained pre- or post-ROSC), pH was 7.03 in poor versus 7.26 in favorable outcome groups ($p<0.001$). In a study by Ganga et al investigating the 7.2 cutoff (22), baseline blood gases were drawn post-ROSC immediately prior to TTM administration. Only in patients with a shockable rhythm was $pH<7.2$ associated with poor neurologic outcomes ($p<0.001$). In the prediction models integrating pH thresholds as adverse prognostic factors, C-GRaPH (14) utilizes 7.0 and the TTM risk score (16) assigns -1 points for $pH \geq 7.35$, 0 for 7.2-7.34, 1 for 7.05-7.19, 2 for 6.9-7.04, and 3 for <6.9 towards a total score of -2 to 35.

Interpreting the clinical implications of post-arrest pH will always require contextualization. A lower pH is expected peri-arrest during ongoing CPR due to a no-flow/low-flow state. A higher pH is expected further after ROSC, both due to improved hemodynamics and the ability of clinicians to empirically optimize acid-base status via mechanical ventilation and medication administration (e.g. sodium bicarbonate). As such, the transitive application of prior studies utilizing pH levels drawn peri-CPR versus post-ROSC/pre-TTM initiation is fraught with the clinical implications of inappropriate pessimism or false optimism respectively. For example, in a study examining pH at both ED and ICU presentations, the mean favorable pH was 7.22 in the ED and 7.40 in the ICU

versus poor pH 7.12 in the ED and 7.35 in the ICU (23). The prognostic interchangeability of arterial and venous pH in the OHCA patient is also of importance. Though multiple prior studies (27, 28) have described a +0.03 correction factor to convert from venous to arterial pH in patients with normal cardiac output, peri-arrest venous pH has been shown to be 0.2-0.35 lower (27, 29, 30), and post-ROSC >0.1 lower (30, 31). As such, in the OHCA population, whether peri-CPR or post-ROSC, arterial and venous pH should likely not be considered interchangeable.

Given these myriad factors that affect the generalizability of the initial post-arrest pH, clinical prognostication related to pH values in isolation should be limited in scope. Based on our study data, there is a strong suggestion that current guidelines likely attribute inappropriate pessimism at a pH threshold of 7.2. Instead, <7.1, or perhaps even <7.05 would be more appropriately considered an unfavorable resuscitation feature. Nevertheless, across studies, there is no consistent pH threshold below which a favorable neurologic outcome is impossible (i.e. 100% specific). In our population, the lowest post-ROSC pH in a patient experiencing a favorable neurologic outcome was 6.94, however reports exist of full neurologic recovery at pH 6.33-6.85, primarily occurring in young patients with known cardiovascular triggers of arrest (32).

Instead, the use of initial pH as part of an existing prediction model to direct prognostication and perhaps clinical decision-making is more appropriate, albeit still controversial. Whereas in our data set pH ≤ 7.10 as a univariable predictor produced a c-

statistic of 0.65, C-GRaPH, utilizing $\text{pH} \leq 7.0$ as a component, generated a c-statistic of 0.88.

Limitations

Our study has several limitations. Although propensity-adjustment was performed to adjust for confounding, we cannot exclude the persistent influence of unmeasured confounding variables. Certain factors that could have directly affected the pH, including the presence of mechanical ventilation and the amount of pre-pH sodium bicarbonate administered were not readily available and thus not accounted for. Additionally, in order to achieve adequate covariate balance, the sample size of the weighted controls was reduced to 24-37% of the treatment group size. As for the exposure variable, though the initial pH was homogeneously arterial (different from many of the prior studies) and ≤ 2 hours post-ROSC, the exact time between ROSC and pH is no longer available and was not recorded and controlled for in statistical analysis. As such, a pH resulting minutes post-ROSC as compared to after an hour of post-arrest critical care may still be too clinically heterogeneous to be reasonably compared.

Future Directions

Prior literature on post-OHCA prognostication has regularly treated pH and lactic acid as interchangeable analogues. However, in our study population, the Pearson correlation coefficient is only -0.48 and Makino et al reported that only 50% of the metabolic acidosis observed post-arrest is explained by lactic acid (33). In our study population, initial lactic acid and initial pH perform similarly as univariable predictors, both as continuous variables (c-statistic: 0.68 lactic, 0.71 pH; Nagelkerke R^2 : 0.10 lactic, 0.13 pH) and at binary algorithm-identified “unfavorable resuscitation feature” thresholds (19) of >7 for lactic acid and <7.2 for pH respectively (c-statistic: 0.61 lactic, 0.67 pH; Nagelkerke R^2 : 0.05 lactic, 0.11 pH). However, in a prior study comparing both simultaneously (34), while pH was significantly associated with poor neurologic outcome (6.93 poor, 7.26 favorable), lactic acid levels were not significantly different (9.6 poor, 8.2 favorable), the latter a finding corroborated by Starodub et al (35). However, in the studies that did show significant associations between lactic acid and neurologic outcome, the mean initial lactic acid reported in the poor outcome group was consistently higher than the algorithm-derived cutpoint >7 (34, 36, 37), with Mullner et al showing 100% specificity for poor neurologic outcome only at >16 mmol/L (37). As such, both a propensity-adjusted analysis of lactic acid in a similar fashion to pH, as well as an analysis of various pH/lactic acid combinations is needed.

Conclusions

Decrements in initial post-resuscitation arterial pH after out-of-hospital cardiac arrest are not associated with progressively poorer neurologic outcomes until ≤ 7.10 , below which, outcomes markedly worsen. This identified threshold is more acidic than reported in consensus guidelines, a discrepancy which may currently result in overly pessimistic prognostication and/or inappropriate withholding of treatment in actual clinical practice. Nevertheless, no consistent pH nadir has yet been identified to allow for further treatment as futile, and as such, the use of initial post-resuscitation pH remains more appropriate as a component in existing prediction models rather than in isolation.

Table 1: Baseline characteristics, pre-arrest medical history, arrest characteristics, and initial post-resuscitation laboratory values for the study patients (n=723) stratified by neurologic outcome (favorable: CPC 1-2; poor; CPC 3-5). Continuous variables are expressed as mean (standard deviation) and categorical variables as number (percentage).

	Favorable (n=142)	Poor (n=581)	P value
Age (years)	57 (15)	63 (15)	<0.001
Female	41 (29%)	271 (47%)	<0.001
Coronary Artery Disease	32 (23%)	205 (35%)	0.005
Congestive Heart Failure	26 (18%)	187 (32%)	0.002
Diabetes Mellitus	27 (19%)	215 (37%)	<0.001
Witnessed Arrest	119 (84%)	444 (76%)	0.07
Bystander CPR	89 (63%)	295 (51%)	0.01
Shockable Rhythm	125 (88%)	175 (30%)	<0.001
Time to ROSC (minutes)	22 (16)	29 (17)	<0.001
Glucose (mg/dL)	233 (82)	277 (134)	<0.001
Lactic Acid (mmol/L)	6.0 (3.3)	8.6 (4.4)	<0.001
Arterial pH	7.23 (0.11)	7.11 (0.18)	<0.001

Table 2: *Favorable* neurologic outcome rates, as well as odds ratios for *poor* neurologic outcome are shown, stratified by decremental thresholds of initial arterial post-ROSC pH. The odds ratios presented are both pre-adjustment and the combination of ATT-weighting on the inverse propensity score and direct regression adjustment for the linear propensity score. Pre- and post-adjustment, there is no significant increased hazard until post-ROSC pH≤7.10, but post-adjustment the odds ratio magnitudes are essentially halved.

pH Threshold	Favorable Neurologic Outcome (n)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
7.30	16.7% (101/605)	2.7 (1.7-4.1)	2.0 (1.0-4.0)
7.25	14.4% (76/529)	3.1 (2.1-4.5)	1.9 (1.2-3.1)
7.20	10.8% (47/435)	4.1 (2.8-6.0)	2.1 (1.3-3.3)
7.15	9.6% (34/354)	3.9 (2.6-5.9)	1.9 (1.2-3.1)
7.10	7.3% (20/275)	4.8 (2.9-7.9)	2.4 (1.4-4.1)
7.05	4.6% (10/218)	7.4 (3.8-14)	3.1 (1.5-6.3)
7.00	3.0% (5/164)	10 (4.2-26)	4.5 (1.8-12)

Table 3: Absolute value of the standardized differences of the logit of the propensity score (Rubin's 1st balance criteria) and ratio of variances of the linear propensity score (Rubin's 2nd balance criteria) below and above each iterative pH threshold. The values are displayed pre-adjustment and after the combination of ATT-weighting on the inverse propensity score and direct regression adjustment for the linear propensity score. At a minimum, <50% is required for the 1st criteria (ideal <10%) and 0.5-2 for the 2nd criteria (ideal 0.8-1.25). Pre-adjustment, the 1st criteria is violated at all thresholds, the 2nd criteria at the 7.30 threshold. Post-adjustment, there is marked improvement, with both criteria satisfied and nearly meeting ideal targets at all pH thresholds

pH Threshold	1st Criteria Pre (%)	1st Criteria Post (%)	2nd Criteria Pre	2nd Criteria Post
7.30	84	13	2.23	1.24
7.25	83	5	1.85	0.95
7.20	88	8	1.6	0.84
7.15	94	7	1.52	0.88
7.10	95	5	1.23	0.93
7.05	107	3	1.17	0.97
7.00	109	5	1.03	0.93

Table 4: Sample size of weighted compared to unweighted controls versus the sample size of treatment patients

pH Threshold	Treatment	Unweighted Control	Weighted Control (%)
7.30	605	118	44 (37%)
7.25	529	194	60 (31%)
7.20	435	288	78 (27%)
7.15	354	369	90 (24%)
7.10	275	448	140 (31%)
7.05	218	505	124 (25%)
7.00	164	559	150 (27%)

Figure 1: Standard definitions of cerebral performance category (CPC) with 1-2 considered favorable and 3-5 a poor neurologic outcome.

Cerebral Performance Category (CPC)

- 1** - Good cerebral performance: conscious, alert, able to work, might have mild neurologic or psychological deficit;
- 2** - Moderate cerebral disability: conscious, sufficient cerebral function for independent activities of daily life, able to work in sheltered environment;
- 3** - Severe cerebral disability: conscious, dependent on others for daily support because of impaired brain function, ranges from ambulatory state to severe dementia or paralysis;
- 4** - Coma or vegetative state: any degree of coma without the presence of all brain death criteria. Unawareness, even if appears awake (vegetative state) without interaction with environment; may have spontaneous eye opening and sleep/awake cycles, cerebral unresponsiveness;
- 5** - Brain death: apnea, areflexia, EEG silence, etc.

Figure 2: Distribution of initial post-ROSC arterial pH stratified by neurologic outcome. The dotted lines represent the mean pH values for the neurologic outcome groups: favorable 7.23 (95% CI 7.01-7.45), poor 7.11 (95% CI 6.76-7.46)

Figure 3. Density plots of the raw propensity score by pH thresholds

Figure 4. Love plot demonstrating markedly improved covariate balance after propensity adjustment

Standardized Differences Pre/Post-ATT Weighting

pH 7.10

Standardized Differences Pre/Post-ATT Weighting

pH 7.05

Standardized Differences Pre/Post-ATT Weighting

Figure 5. Pre- and post-adjustment odds ratios for poor neurologic outcome by pH thresholds

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