

The prognostic value of on-arrival arterial blood gas parameters in out-of-hospital cardiac arrest: pH versus pCO₂ for predicting ROSC

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ABSTRACT

Objective: Predicting ROSC in OHCA patients undergoing CPR, through on-arrival blood gas components, can help guide intensive clinical decision-making in already overburdened and understaffed emergency departments of low and middle-income countries like Pakistan.

Material and Methods: This prospective observational study was conducted at an urban teaching hospital facility for a period of 3 years and included 156 consecutively selected non-trauma OHCA patients undergoing CPR. Blood gas analysis was done on arrival at the emergency department. Baseline values, arterial pH, and pCO₂ levels were compared between the two groups (ROSC-achieved vs ROSC-not-achieved). Multiple logistic regression analysis identified independent ROSC predictors, and the ROC study compared the discriminative capacity of pH and pCO₂.

Results: The ROSC-achieved group exhibited significantly higher arterial pH than the other group (mean difference = 0.12, 95% CI: 0.06-0.18, $p < 0.001$). No significant difference in mean pCO₂ was found between the groups ($p = 0.29$). In the multiple logistic regression analysis, greater pH independently predicted ROSC (OR = 71.07, 95% CI: 4.11–1227.04; $p = 0.003$) while pCO₂ was not independently associated (OR = 1.02, 95% CI: 0.98-1.04, $p = 0.29$). The ROC analysis showed that pH has a higher discriminative capacity (AUC = 0.68) than pCO₂ (AUC = 0.44).

Conclusion: The study found that arterial pH in the on-arrival blood gas sample can independently predict ROSC in OHCA patients undergoing CPR. Keywords: ABGs (arterial blood gases), OHCA (out-of-hospital cardiac arrest), pCO₂ (Partial pressure of carbon dioxide), ROSC (return of spontaneous circulation)

Keywords: OHCA, CPR, Blood gas analysis, ROSC.

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INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is a pressing public health burden globally, and the outcomes are especially bleak in low- and middle-income countries (LMICs). In Pakistan, the survival-to-hospital admission and discharge rates after OHCA are extremely low, around 4.88% and 0.7%, respectively, signifying severe scarcity of prehospital care, lag time to resuscitation, and limited emergency department (ED) capacity [1,2]. These results highlight the importance of timely prognostic markers that guide emergency physicians in making patient management decisions, especially in overcrowded and understaffed emergency facilities. Cardiac arrest causes sudden

loss of effective circulation with subsequent global hypoperfusion, tissue hypoxia, and accumulation of metabolites. This chain of events generates significant derangements in acid-base balance, specifically global changes in arterial

pH and blood pCO₂, which mirror the severity and duration of cellular ischemia. During resuscitation, the ABG parameters play an important role in obtaining information about the patient's physiological condition and the probability of achieving ROSC. Such objective biochemical surrogates may be useful to augment clinical impressions of CPR and serve as a basis for stopping or further escalating resuscitation [3-6]

A variety of biochemical and blood gas factors have been variously associated with ROSC, including partial pressure of oxygen, stabilization in oxygen tension, lactate, pCO₂ (partial pressure CO₂), ammonia, and potassium concentrations, as well as base excess and glucose levels [7–15]. Many of these parameters have demonstrated some correlation with resuscitation results. Nevertheless, most available data come from blood samples drawn at time points of or after resuscitation and may therefore have limited

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application as early predictors. As such, on arrival, arterial blood gas analysis, which is undertaken in the early phase of hospital resuscitation in patients with OHCA, has not been adequately investigated as a predictor for patients who experience OHCA [16–19]. Large-scale studies have led to a revival of interest in acid–base parameters as predictors for prognosis. Another study with more than 1,500 OHCA patients also found that lower arterial pH or higher pCO₂ levels were independently associated with decreased probability for ROSC, suggesting the importance of profound metabolic and respiratory derangements in unsuccessful CPR. Other studies have also found that pH is an important physiologic variable affecting ROSC, and both pH and pCO₂ are lower in the setting of resuscitation compared with pre-arrest values, though a clear graded relationship exists between low pH and worse rates of return to spontaneous circulation [16,17].

Although increasing evidence supports the prognostic importance of acid–base disturbances in OHCA, a knowledge gap persists regarding the relative predictive performance of on-arrival arterial pH compared to pCO₂, specifically in LMIC settings where pre-hospital resuscitation is minimal or lacking. Fast, accessible parameters such as ABG values may thus represent an important tool in the guidance of real-time clinical decisions during resuscitation.

The primary objective of this study was to assess the prognostic role of on-arrival arterial pH and pCO₂ for ROSC in OHCA patients, and to compare their predictive power. To the author's knowledge, there has been little done about this in a middle-income country like Pakistan. By finding these early biochemical predictors of ROSC, this study tries to establish more specific evidence that can aid emergency physicians in making decisions on appropriate resuscitation measures and resource allocation, with resource-constrained prehospital care.

MATERIAL AND METHODS

This prospective observational study was conducted over three years, from February 2021 to January 2024 after approval of CPSP research evaluation unit (vide reference number CPSP/REU/EMD-2018-153-129 dated 30 Dec 2020), at the emergency department of an urban teaching hospital in Pakistan, which receives around 80,000 visits annually. In Pakistan, emergency medical services (EMS) are a combination of public and private services, supplemented by services like the massive Edhi Foundation's volunteer ambulances.

However, the system faces substantial obstacles, like a shortage of experienced workers and discrepancies in access to care between urban and rural areas. Providers are instructed to scoop and run to the ED as soon as possible. EMS is not legally permitted to proclaim death in the field until there are apparent indications incompatible with life. Public sector EMS staff are often undereducated in Basic Life Support, which includes providing chest compressions and ventilation via a bag-mask device, as well as using an automated external defibrillator (AED). The majority of them are not qualified to perform advanced airway management or administer intravenous drugs during CPR.

The study included all consecutive adult (age 18 - 70 years) nontraumatic OHCA patients, using a non-probability, consecutive sampling technique. During the trial, all OHCA patients had a blood sample drawn within 5 minutes of arriving at the ED. Patients were excluded if blood sampling was delayed (more than 5 minutes), if they achieved ROSC within 5 minutes or before hospital arrival, or if they were on a do-not-resuscitate order. Sustained ROSC was defined as having a perceptible pulse for more than one hour. Before we began this investigation, the hospital's Institutional Review Board approved it and waived the necessity for informed consent.

We documented the following information using the questionnaire designed specifically for this study: demographic characteristics (age and gender), previous comorbidities, transit time, initial cardiac rhythm at the hospital, initial blood gas data within 5 minutes of ED arrival (pH and PCO₂), and outcome (achievement of sustained ROSC).

Data collection questionnaire

Basic Life Support (BLS) and Advanced Cardiovascular Life Support (ACLS) were performed in accordance with the Basic and Advanced Cardiac Life Support algorithms (published in 2020). Blood gas analysis was performed using a Nova Biomedical Stat Profile blood gas analyzer with the following detection ranges: blood pH, 6.50-8.00; pCO₂, 3-200 mmHg; pO₂, 0- 760 mmHg. Blood samples were collected in heparinized syringes from the first IV placed in the patient, considering the difficult job of getting an arterial sample in patients undergoing CPR. (20) To minimize measurement bias, blood gas samples were obtained within a standardized 5-minute window using the same analyzer for all patients.

The calculated sample size was 100, using the WHO calculator (7.1) with a 95% confidence level, an

anticipated mean of 78, a standard deviation of 8.75, and an absolute precision of 1. (19). As the study period spanned three years, 156 eligible patients (more than the calculated sample size) were enrolled in the study cohort, due to the departmental resuscitation policy for do-not-attempt resuscitation for the patients : ≥ 80 years old, time since arrest > 30 minutes, metastatic disease, bed-bound status with chronic diseases (like CKD, CCF, CLD, ILD, Stroke), functional status of Modified Rankin Score ≥ 4 , trauma patients with no signs of life and patients' own decisions for do-not-attempt resuscitation. Continuous variables (age, transit time, and values of arterial pH and pCO₂) and categorical variables (gender, initial rhythm category, shockable vs non-shockable rhythm, and ROSC status) were statistically analyzed by appropriate tests as explained below.

Continuous variables were reported as mean $\pm$ standard deviation (SD) when normally distributed and median with interquartile range (IQR) when non-normally distributed. The Kolmogorov-Smirnov test was used to determine whether a dataset follows a normal distribution. Categorical variables such as gender, initial rhythm (shockable vs non-shockable), and CPR outcome (ROSC achieved vs ROSC-not-achieved) were represented as absolute numbers and percentages. To compare the values of arterial pH and pCO₂ between ROSC-achieved and ROSC-not-achieved groups, an independent samples t-test was used for normally distributed data. An independent sample t-test was used to compare the age between the two groups. For non-normally distributed continuous data, the Mann-Whitney U test was used. Differences between categorical variables were evaluated using Fisher's exact test. Demographic and biochemical characteristics were first reported with p-values. For multiple logistic regression analysis, independent variables such as age, gender, initial rhythm, on-arrival arterial pH, pCO₂, and transit time, while the dependent variable of CPR outcome (ROSC achieved vs ROSC-not-achieved) were selected. Independent samples t-test, Mann-Whitney U test, Fisher's exact test, and Wald statistics from multiple logistic regression, as appropriate, were used to compute p-values. A 2-tailed P value of less than 0.05 was judged statistically significant. The odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to summarize the results. For the logistic regression model, the Hosmer-Lemeshow test was used. A receiver operating characteristic (ROC) curve and the area under the ROC curve (AUC) compared

the predictive power of pH and pCO₂ for ROSC. All statistical analyses were conducted using SPSS version 25.0 (IBM, Armonk, NY). For reporting the observational study, the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist was used.

RESULTS

The study enrolled 156 patients, while 29 were removed for missing values of pH and pCO₂ (instrument errors) using listwise deletion. Most of the patients were either brought by passersby, or attendants were unsure of the comorbidities of their patients, so this variable was removed in the final analysis. The final analyzable sample had 127 patients (more than the calculated sample size of 100), divided into two groups (ROSC-achieved group and ROSC-not-achieved group). Among those who achieved ROSC, two died before shifting to the intensive care unit, 14 had their post-ROSC care in the ICU, and most patients were admitted to the coronary care unit, as shown in Figure-I.

The baseline demography and biochemical characteristics are given in Table I. The study population, predominantly male, had a mean age of 58.5 ± 14.8 years. No statistically significant difference in age between patients of the two groups was observed ($p = 0.14$). Gender distribution differed significantly between the two groups ($p = 0.01$), with male patients having a lower ROSC rate. On arrival, asystole was the most common rhythm, followed by PEA, ventricular fibrillation (VF), and pulseless ventricular tachycardia, respectively. Patients presenting with VF had the highest ROSC rate, whereas asystole was associated with the lowest one. Patients having a no-flow time of ≤ 10 minutes had a higher ROSC rate compared to those with no-flow times > 10 minutes ($p = 0.001$), highlighting the strong influence of early resuscitation on outcomes. The ROSC group had a higher arterial pH on arrival compared to the other group ($p < 0.001$), while pCO₂ levels did not differ significantly between the groups ($p = 0.29$). Table-I Baseline characteristics and biochemical parameters of OHCA patients stratified by ROSC status.

A multiple logistic regression analysis identified independent predictors of return of spontaneous circulation (ROSC) with ROSC as the dependent variable, and an OR < 1 indicated reduced odds of achieving ROSC. An on-arrival high arterial pH was found to be an important ROSC predictor. After

rescaling, each 0.1-unit increase in arterial pH was independently associated with higher odds of achieving ROSC, indicating that less severe acidosis on arrival increased the chances of achieving ROSC. Shorter transit time was moderately associated with better odds of achieving ROSC, and the likelihood of achieving ROSC was decreased by approximately 5% with every minute increase in transit time. Male gender had lower odds of achieving ROSC, while age, pCO₂, and initial shockable rhythm did not independently predict ROSC after adjustment, as shown in Table-II.

To evaluate the discriminatory ability of arterial pH for predicting ROSC, Receiver operating characteristic (ROC) curve analysis was performed, as shown in Figure-II. The area under the curve (AUC) for pH was 0.68 (SE = 0.05, 95% CI: 0.59–0.77, $p = 0.001$), indicating fair predictive accuracy and a meaningful prognostic value for identifying patients likely to achieve ROSC. pCO₂ had an AUC = 0.44, with its ROC curve remaining below the reference diagonal, indicating its limited standalone utility as shown in Figure-II.

Table-I: Baseline characteristics and biochemical parameters of OHCA patients stratified by ROSC status.

Parameters	Total (n=127)	ROSC Achieved (n=57)	ROSC Not Achieved (n=70)	P-value	
Age (years)				0.14	
Mean ±SD	58.5 ±14.8	56.3 ±15.9	60.2 ±13.7		
Gender				0.01	
Male	86	32 (37.2%)	54 (62.8%)		
Female	41	25 (60.9%)	16 (39.1%)		
Initial rhythm on hospital arrival					
VF	19	14 (73.7%)	5 (26.3%)		
pVT	7	2 (28.6%)	5 (71.4%)		
PEA	35	20 (57.1%)	15 (42.9%)		
Asystole	66	21 (31.8%)	45 (68.2%)		
Shockable vs. non-shockable rhythm				0.056	
Non-shockable (PEA, Asystole)	101	41 (40.6%)	60 (59.4%)		
Shockable (VF, pVT)	26	16 (61.5%)	10 (38.5%)		
No-flow time				0.001	
Median (IQR)					
10 minutes (15)					
≤ 10 minutes	64	38 (66.7%)	26 (37.1%)		
>10 minutes	63	19 (33.3%)	44 (62.9%)		
Survival to admission	55 (96.5%)	55 (96.5%)			
Blood gas analysis	Mean Difference (95%CI)			P value	t(df)
pH	0.12 (0.06 – 0.18)	7.1 ±0.15	6.98 ±0.20	<0.001	3.69 (125)
pCO ₂ (mmHg)	- 2.94 (-8.47 – 2.58)	49 ±18.2	52 ±13.3	0.29	- 1.05 (100)

Table-II: Multiple logistic regression analysis for factors predicting return of spontaneous circulation.

S. No	Variables	P value	OR	95% CI	
				Lower	Upper
1.	pH	0.003	71.07	4.11	1227.04
2.	Transit time	0.03	0.95	0.90	0.99
3.	Male Gender	0.001	0.21	0.08	0.54
4.	pCO ₂	0.29	1.02	0.98	1.04
5.	Initial shockable rhythm	0.25	0.55	0.19	1.53
6.	Age	0.13	0.98	0.95	1.007

Figure-I: Cardiac arrest patients and study participants ROSC (Return of Spontaneous Circulation).

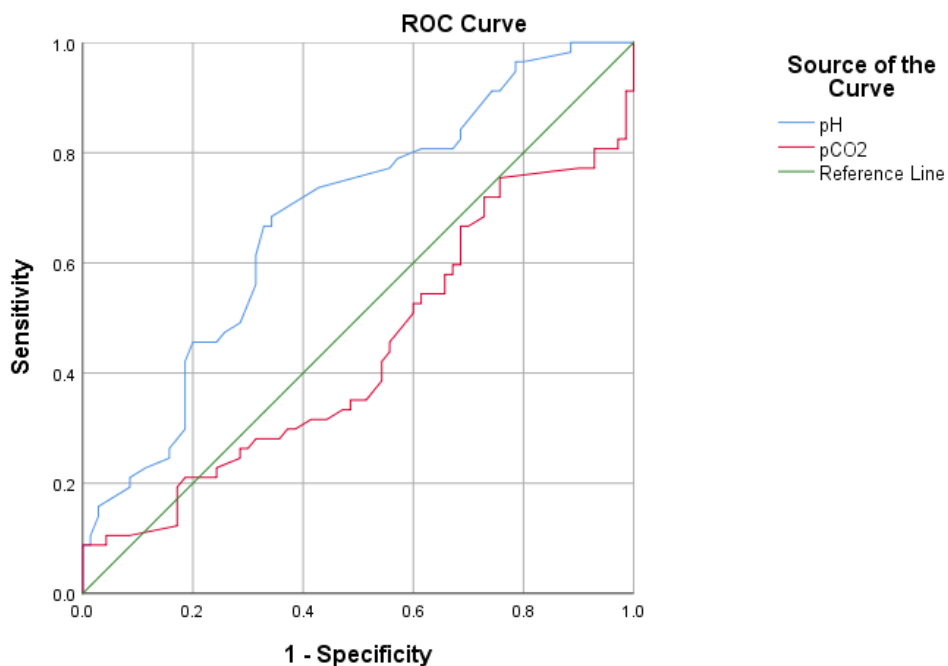
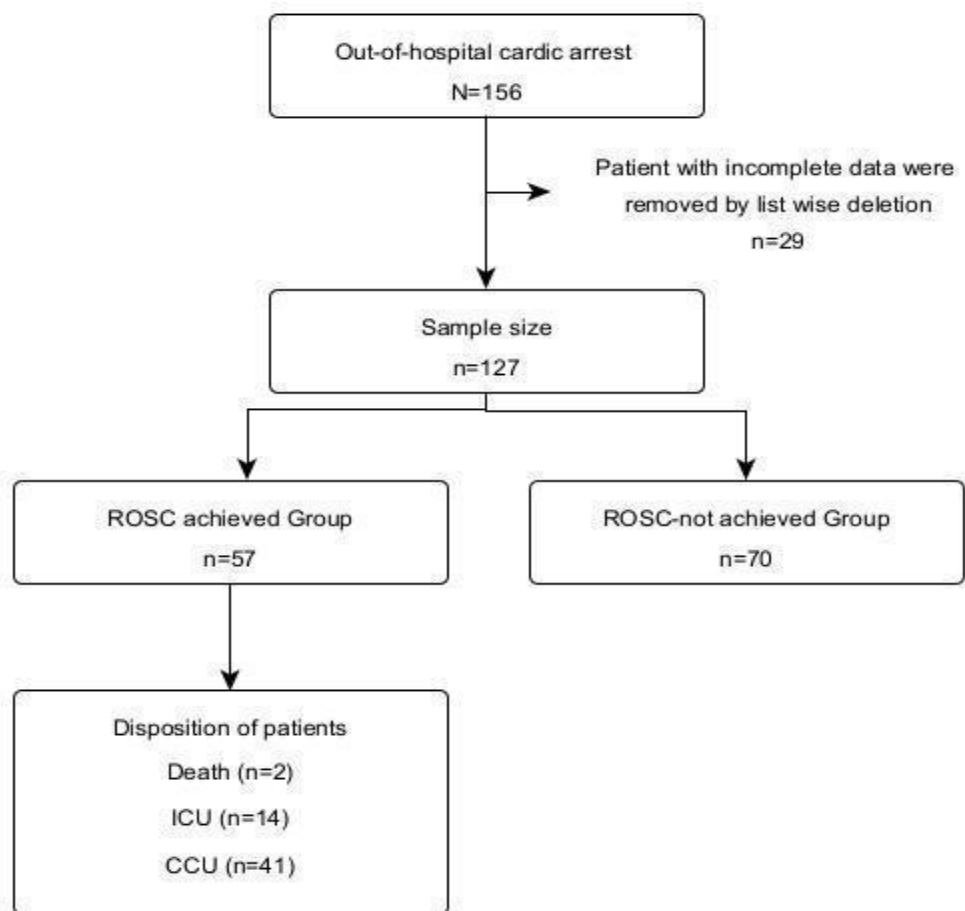


Figure-II. ROC curve showing the predictive performance of arterial pH and pCO₂ for ROSC.

DISCUSSION

In the study, a higher on-arrival arterial pH was found to be independently associated with increased odds of achieving ROSC in OHCA patients and was more predictive than pCO₂. The ROC analysis confirmed this by comparing AUC for both pH and pCO₂ (AUC for pH = 0.68), limiting the usefulness of pCO₂ in ROSC prediction. This relationship of improved ROSC outcomes observed with an elevated arterial pH is consistent with the data suggesting that metabolic acidosis (indicated by a low pH) delineates more severe global hypoxia and tissue ischemia. While acidosis is common to all no-flow/low-flow states in cardiac arrest, higher pH measures may reflect briefer ischemia times or more effective early resuscitative efforts associated with better outcomes [4,5,8]. A large population study has demonstrated that models that included arterial pH were comparable to traditional predictors like low-flow time and had improved predictive performance when combined with other clinical factors, underscoring the prognostic potential of pH in OHCA prognosis research [18].

Arterial pH as a prognostic variable in our study exhibits biological plausibility. During cardiac arrest, the cessation of effective circulation removes both oxygen delivery and CO₂ elimination, resulting in progressive lactic and respiratory acidosis. Increased acidosis is accompanied by a greater degree of anaerobic metabolism and cellular dysfunction, which impairs myocardial and cerebral integrity. These findings are in line with a prior observational study that documented lower pH values associated with weaker ROSC and survival outcomes, respectively [19]. The pH exhibits a very narrow physiological range, meaning a slight change in pH can have important clinical implications, so we interpreted the Logistic regression analysis after re-scaling for pH. Each 0.1-unit increase in arterial pH was independently associated with higher odds of achieving ROSC, indicating that less severe acidosis on arrival increased the chances of achieving ROSC.

This study did not find an independent predictive value for pCO₂, which is in contrast to some prior studies reporting pCO₂ as an important ROSC predictor, particularly in ED-based studies or subgroups of patients [21]. Variable prehospital resuscitation and airway management/ventilation quality (associated with PCO₂) might be the cause of this inconsistency. Secondly, pCO₂ can be a measure of acute rather than chronic respiratory status and not necessarily indicate an overall hypoperfusion/

metabolic disturbance. Third, discordant findings in the literature suggest that the prognostic significance of pCO₂ may be situation-specific and affected by sampling time, bystander CPR quality, and overall EMS effectiveness [19, 21].

The moderate predictive value of transit time for ROSC in our study supports the fact that shorter ischemic times reduce the degree of metabolic acidosis and overall end-organ injury, thereby increasing the ROSC possibility. This supports a number of resuscitation registries that demonstrate poorer outcomes for every additional minute without effective circulation [17]. Males were found to have decreased odds of ROSC on multivariate analysis. Although previous studies have described gender disparities in cardiac arrest survival, the reasons for these differences are not well established.

The two groups tested in this study were not even with each other in number, as 29 patients had to be excluded from our analysis because of missing values. However, Levene's test reported the homogeneity of variances among groups sufficient to justify the parametric comparisons. Therefore, the disparity in mean arterial pH between groups is less likely to reflect group-size imbalance. ROSC was defined as the attainment and maintenance of spontaneous circulation for at least one hour in order to minimize misclassification and more accurately capture only clinically relevant resuscitation outcomes.

LIMITATIONS

The study's limitations include a single-center cohort with most patients receiving no prehospital resuscitation, a common scenario in low- and middle-income countries (LMICs). This likely exacerbates the extent of metabolic derangement evident on admission, and comparisons with EMS-laden environments are difficult [9,11]. Second, the observational nature of our study precludes concluding causality and residual confounding by unmeasured variables (e.g., CPR quality, time to advanced airway). Third, ABG values, obtained rapidly, can still vary in sampling time with different resuscitation stages and may impact prognostic interpretation – a limitation highlighted in recent systematic analyses of blood gas prognostic utility. [18]. Additionally, the neurological status of resuscitated patients was not reported, with the ROSC being the only outcome documented.

RECOMMENDATIONS

Future multi-center prospective studies with a larger sample size can help confirm these findings, such as arterial pH, in predicting ROSC among patients after OHCA. As neurological recovery is an important part of post-resuscitative success, future studies can consider this variable as a key outcome.

CONCLUSION

This study's findings support that initial arterial pH is an independent and clinically meaningful predictor of ROSC, outperforming pCO₂. On-arrival arterial pH can be used as an immediately available, objective prognostic marker of ROSC in OHCA patients with limited prehospital care, in resource-constrained emergency departments.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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Declared none

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AUTHORS CONTRIBUTION

Ayesha Saeed: Substantial contributions to study design, acquisition of data, manuscript drafting, reviewing it critical for important intellectual content, final approval, accountable for all aspects of publication.

Syeda Javeria Ahsan: Substantial contributions to study design, acquisition of data, final approval, accountable for all aspects of publication

Sana Shafique: Substantial contributions to study design, acquisition of data, manuscript drafting, reviewing it critical for important intellectual content, final approval, accountable for all aspects of publication

Turab Fatima Abidi: final approval, accountable for all aspects of publication

REFERENCES

1. Baig MN, Fatmi Z, Khan NU, Khan UR, Raheem A, Razzak JA. Characteristics and outcomes of out-of-hospital cardiac arrest in rural and suburban areas of Sindh, Pakistan: A cross-sectional study. *Resusc Plus*. 2025; 21: 100840. DOI: <https://doi.org/10.1016/j.resplu.2024.100840>
2. Khan UR, Baig N, Bhojwani KM, Raheem A, Khan R, Ilyas A, *et al*. Epidemiology and outcomes of out-of-hospital cardiac arrest in Karachi, Pakistan: a longitudinal study. *Resusc Plus*. 2024; 20: 100773. DOI: <https://doi.org/10.1016/j.resplu.2024.100773>
3. Lee SH, Shin H, Cho Y, Oh J, Choi HJ. Korean Cardiac Arrest Research Consortium (KoCARE) Investigators. Arterial blood gas analysis for survival prediction in pediatric patients with out-of-hospital cardiac arrest. *J Pers Med*. 2023; 13(7): 1061. DOI: <https://doi.org/10.3390/jpm13071061>
4. Wang HE, Prince DK, Drennan IR, Grunau B, Carlhom DJ, Johnson N, *et al*. Post-resuscitation arterial oxygen and carbon dioxide and outcomes after out-of-hospital cardiac arrest. *Resuscitation*. 2017; 120: 113-8. DOI: <https://doi.org/10.3390/jpm13071061>
5. Shehadeh AA, Feng J, Selde W, Billian J, Mastenbrook J. Higher prehospital blood glucose levels associated with return of spontaneous circulation in out-of-hospital nontraumatic cardiac arrests. *Air Med J*. 2023; 42(6): 471-6. DOI: <https://doi.org/10.1016/j.amj.2023.09.003>
6. Nishioka N, Kobayashi D, Izawa J, Irisawa T, Yamada T, Yoshiya K, *et al*. Association between serum lactate level during cardiopulmonary resuscitation and survival in adult out-of-hospital cardiac arrest: a multicenter cohort study. *Sci Rep*. 2021; 11(1): 1639. DOI: <https://doi.org/10.1038/s41598-020-80774-4>
7. Patel NT, Carr CT, Hopson CM, Hwang CW. Lactate and pH as independent biomarkers for prognosticating meaningful post-out-of-hospital cardiac arrest outcomes: a systematic review and meta-analysis. *J Clin Med*. 2025; 14: 2244. DOI: <https://doi.org/10.3390/jcm14072244>
8. Nojima T, Naito H, Obara T, Ageta K, Yakushiji H, Yumoto T, *et al*. Can blood ammonia level, prehospital time, and return of spontaneous circulation predict neurological outcomes of out-of-hospital cardiac arrest patients? A nationwide, retrospective cohort study. *J Clin Med*. 2022; 11(9): 2566. DOI: <https://doi.org/10.3390/jcm11092566>
9. Nakamichi Y, Ichibayashi R, Watanabe M, Suzuki G, Serizawa H, Yamamoto S, *et al*. Improved neurological outcome of perampanel for hypoxic-ischemic encephalopathy in patients after out-of-hospital cardiac arrest resuscitation. *Cureus*. 2023; 15(12): e51392. DOI: <https://doi.org/10.7759/cureus.51392>
10. Huang CY, Lu TC, Tsai CL, Wu CY, Chou EH, Wang CC, *et al*. Using point-of-care testing for adult patients with out-of-hospital cardiac arrest resuscitated at the emergency department to predict return of spontaneous circulation: development and external validation of POC-ED-ROSC model. *Am J Emerg Med*. 2023; 71: 86-94. DOI: <https://doi.org/10.1016/j.ajem.2023.06.022>
11. Hong SI, Kim JS, Kim YJ, Kim WY. Dynamic changes in arterial blood gas during cardiopulmonary resuscitation in out-of-hospital cardiac arrest. *Sci Rep*. 2021; 11(1): 23165. DOI: <https://doi.org/10.1038/s41598-021-02764-4>

12. Robba C, Siwicka-Gieroba D, Sikter A, Battaglini D, Dąbrowski W, Schultz MJ, *et al.* Pathophysiology and clinical consequences of arterial blood gases and pH after cardiac arrest. *Intensive Care Med* Exp. 2020; 8(1): 1-13.
DOI: <https://doi.org/10.1186/s40635-020-00307-1>
13. Okada A, Okada Y, Kandori K, Nakajima S, Okada N, Matsuyama T, *et al.* Associations between initial serum pH value and outcomes of pediatric out-of-hospital cardiac arrest. *Am J Emerg Med*. 2021; 40: 89-95.
DOI: <https://doi.org/10.1016/j.ajem.2020.12.032>
14. Corral Torres E, Hernández-Tejedor A, Suárez Bustamante R, de Elías Hernández R, Casado Flórez I, San Juan Linares A. Prognostic value of venous blood analysis at the start of CPR in non-traumatic out-of-hospital cardiac arrest: association with ROSC and the neurological outcome. *Crit Care*. 2020; 24: 1-8.
DOI: <https://doi.org/10.1186/s13054-020-2762-5>
15. Latest in resuscitation research: highlights from the 2021 American Heart Association's Resuscitation Science Symposium. *J Am Heart Assoc*. 2022; 11: e026191.
DOI: <https://doi.org/10.1161/jaha.122.026191>
16. Wang S, Wang M, Yan DH, Liu Y, Zhou S, Fang J, *et al.* Analysis of the relationship between the characteristics of the blood internal environment and early prognosis in patients with cardiac arrest. *Res Square*. 2024.
DOI: <https://doi.org/10.21203/rs.3.rs-5242984/v1>
17. Jeong D, Shin SD, Shin TG, Lee GT, Park JE, Hwang SY, *et al.* Initial arterial pH predicts survival of out-of-hospital cardiac arrest in South Korea. *Acute Crit Care*. 2025; 40(3): 444-51.
DOI: <https://doi.org/10.4266/acc.001050>
18. Ghazala M, Alkodami L, Farhat NMN, Alkhabour ST, Zain Al-Abiden MS, Jihwaprani MC, *et al.* Prognostic value of point-of-care blood gas values to predict cardiopulmonary resuscitation outcome in out-of-hospital cardiac arrest patients: a systematic review. *J Emerg Med*. 2025; 80: 266-75.
DOI: <https://doi.org/10.1016/j.jemermed.2025.09.024>
19. Kim YJ, Lee YJ, Ryoo SM, Sohn CH, Ahn S, Seo DW, *et al.* Role of blood gas analysis during cardiopulmonary resuscitation in out-of-hospital cardiac arrest patients. *Medicine (Baltimore)*. 2016; 95(25): e3960. DOI: <https://doi.org/10.1097/md.0000000000003960>
20. Malatesha G, Singh NK, Bharija A, Rehani B, Goel A. Comparison of arterial and venous pH, bicarbonate, PCO₂ and PO₂ in initial emergency department assessment. *Emerg Med J*. 2007; 24(8): 569-571.
DOI: <https://doi.org/10.1136/emj.2007.046979>
21. Su PI, Tsai MS, Chen WT, Wang CH, Chang WT, Ma MH, *et al.* Prognostic value of arterial carbon dioxide tension during cardiopulmonary resuscitation in out-of-hospital cardiac arrest patients receiving extracorporeal resuscitation. *Scand J Trauma Resusc Emerg Med*. 2024; 32(1): 23. DOI: <https://doi.org/10.1186/s13049-024-01195-0>