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Against the Clock: Survival in Pediatric in-hospital Cardiac Arrest

Zamana Karşı: Hastane İçi Pediyatrik Kardiyak Arrest Durumunda Hayatta Kalma

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Abstract

Introduction: Pediatric in-hospital cardiac arrest (IHCA) is associated with high morbidity and mortality, yet factors influencing survival are incompletely understood. The aim of the study is to evaluate factors affecting immediate and short-term survival in IHCA, focusing on cardiopulmonary resuscitation (CPR) duration, initial rhythm, and arrest location.

Methods: This retrospective cohort study included 365 patients aged 1 day to 14 years with IHCA who presented at the King Faisal Specialist Hospital & Research Center, Jeddah, Saudi Arabia between 2013 and 2022. Key resuscitation variables such as CPR duration, initial rhythm, and arrest site were analyzed. The primary outcomes were the return of spontaneous circulation (ROSC) and 28-day survival. Demographic and clinical data, including comorbidities and post-ROSC organ failure, were recorded. Multivariate logistic regression identified independent survival predictors.

Results: The 28-day survival rate was 25.2%. Longer CPR duration was linked to reduced ROSC and 28-day survival [odds ratio (OR)=1.11 per minute; p<0.001]. Median CPR duration was 7 minutes for ROSC compared to when ROSC was not achieved, which was 27 minutes (p<0.001). CPR lasting more than 15 minutes was likely to result in no ROSC, with a strong prediction accuracy of 82%, meaning it correctly identified cases 82% of the time, (p<0.001). IHCA in the emergency department (ED) was associated with ROSC failure (OR=4.12; p=0.006). Initial bradycardia was associated with better survival than asystole or pulseless electrical activity (p=0.031). There was no significant association between CPR duration and post-ROSC organ failure (p>0.05).

Conclusion: CPR duration, initial rhythm, and arrest location significantly influence immediate and 28-day survival in pediatric IHCA. These findings support the need for optimized, rhythm-specific resuscitation strategies, particularly for ED arrests requiring prolonged CPR. Future research should investigate strategies to reduce CPR duration and enhance survival.

Öz

Giriş: Hastane içi pediyatrik kardiyak arrest (HİKA), yüksek morbidite ve mortalite ile ilişkilidir, ancak hayatta kalmayı etkileyen faktörler tam olarak ortaya konulmamıştır. Çalışmanın amacı, kardiyopulmoner resüsitasyon (CPR) süresi, ilk ritim ve arrest lokasyonuna odaklanarak HİKA'da acil ve kısa vadeli hayatta kalmayı etkileyen faktörleri değerlendirmektir.

Yöntemler: Bu geriye dönük kohort çalışması, 2013 ile 2022 yılları arasında Suudi Arabistan'ın Cidde kentindeki King Faisal İhtisas Hastanesi & Araştırma Merkezi'ne başvuran, 1 gün ile 14 yaş arası HİKA'lı 365 hastayı içerdi. CPR süresi, ilk ritim ve arrest lokasyonu gibi önemli resüsitasyon değişkenleri analiz edildi. Birincil sonuçlar, spontan dolaşımın geri dönüşü (ROSC) ve 28 günlük sağkalımdı. Komorbiditeler ve ROSC sonrası organ yetmezliği dahil olmak üzere demografik ve klinik veriler kaydedildi. Çok değişkenli lojistik regresyon ile bağımsız sağkalım belirleyicileri tanımlandı.

Bulgular: Yirmi sekiz günlük hayatta kalma oranı %25,2 idi. Uzun CPR süresi, düşük ROSC ve 28 günlük hayatta kalma oranı ile bağlantılıydı [olasılık oranı (OO)=1,11/dakika; p<0,001]. ROSC için medyan CPR süresi 7 dakika iken, ROSC elde edilemediğinde bu süre 27 dakikaydı (p<0,001). On beş dakikadan uzun süren CPR'nin ROSC ile sonuçlanma olasılığı yüksekti ve bu durumun tahmin doğruluğu %82 idi, yani olguların %82'sinde doğru bir şekilde tespit edildi (p<0,001). Acil serviste (AS) HİKA, ROSC başarısızlığı ile ilişkiliydi (OO=4,12; p=0,006). Başlangıçtaki bradikardi, asistoli veya nabızsız elektriksel aktiviteye göre daha iyi hayatta kalma ile ilişkiliydi (p=0,031). CPR süresi ile ROSC sonrası organ yetmezliği arasında anlamlı bir ilişki yoktu (p>0,05).

Sonuç: CPR süresi, başlangıç ritmi ve arrest lokasyonu, pediyatrik HİKA'da acil ve 28 günlük hayatta kalma oranını önemli ölçüde etkilemektedir. Bu bulgular, özellikle uzun süreli CPR gerektiren AS arrestleri için, ritimlere özgü optimize edilmiş resüsitasyon stratejilerinin gerekliliğini desteklemektedir. Gelecekteki araştırmalar, CPR süresini kısaltmak ve hayatta kalma oranını artırmak için stratejiler üzerinde durmalıdır.

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Abstract

Keywords: Cardiopulmonary resuscitation, in-hospital pediatric cardiac arrest, survival rates

Öz

Anahtar Kelimeler: Kardiyopulmoner resüsitasyon, hastane içi pediyatrik kardiyak arrest, hayatta kalma oranları

Introduction

Pediatric in-hospital cardiac arrest (IHCA) is a critical condition that requires prompt professional management to enhance survival rates.[1-3] Although infrequent, IHCA is linked to considerable morbidity and mortality.[4,5] High-quality cardiopulmonary resuscitation (CPR) is defined as chest compressions with sufficient depth (≥4 cm in infants and ≥5 cm in children), rate (100-120 compressions/min), minimal pauses, complete chest recoil, and adequate ventilation, according to American Heart Association (AHA) Guidelines.[6] The quality and timing of CPR, initial cardiac rhythm, and the location of the arrest are certain factors that affect patients' survival.[7,8] According to AHA Guidelines, high-quality CPR is characterized by proper compression depth, rate, and minimal interruptions that significantly improve survival outcomes.[9] Bradycardia shows better outcomes than other initial rhythms, such as asystole and pulseless electrical activity (PEA), given that interventions remain timely and efficient.[8,10-15]

Adult cardiac arrests have been extensively studied in the literature, particularly regarding the effects of initial rhythm, CPR duration, and arrest location-whether out-of-hospital, in the emergency department (ED), or within specialized units. Several studies have shown that arrests occurring in specialized units, such as the pediatric intensive care unit (PICU) and neonatal intensive care unit (NICU), are associated with better outcomes.[16-19] Given the importance of effective resuscitation and post-resuscitation efforts, alongside the absence of agreement on CPR duration effects and cut-off limits in terms of outcomes, further research is warranted.[8,20,21] Therefore, this research aims to evaluate the effect of CPR duration, initial presenting cardiac rhythm, and arrest location on survival outcomes in pediatric IHCA. In addition, it seeks to identify predictors and factors that influence improved IHCA survival rates. By examining whether prolonged resuscitation is beneficial or detrimental, this study bridges a gap in clinical literature. The findings will provide evidence-based insights for medical stakeholders to inform CPR guidelines, support long-term improvement of pediatric IHCA outcomes, and enhance post-resuscitation care strategies.

Materials and Methods

Study Design and Population

The study adopted a retrospective design, analyzing data from 365 pediatric patients who experienced IHCA at King Faisal Specialist Hospital & Research Center, Jeddah, Saudi Arabia, and received CPR by pediatric advanced life support-certified teams. Patients were aged 1 day to 14 years, and data were collected at our center between January 2013 and December 2022. Those who experienced out-of-hospital cardiac arrest or required extracorporeal CPR following return of spontaneous circulation (ROSC) were excluded to maintain focus. Although the overall sample was substantial, subgroup analyses-particularly comparisons across arrest types-were limited by statistical power. All CPR interventions adhered to the latest AHA Guidelines, sustaining a compression rate of 100-120 per minute, achieving adequate depth, allowing full chest recoil, and minimizing interruptions.[22]

Ethical Considerations

The Institutional Review Board approved the study protocol at King Faisal Specialist Hospital & Research Center, Jeddah, Saudi Arabia (approval number: IRB 2032-82, date: 21.07.2023). Informed consent was waived for this research due to the retrospective nature of the studies. The study strictly adhered to institutional and national data-protection policies before data collection. To ensure confidentiality, all medical records were de-identified prior to analysis and access was restricted solely to authorized investigators. This research also complied with institutional rules and national guidelines for the use of patient records in retrospective studies.

Data Collection

Data were collected from participants' medical records, including demographic information (age, gender, and postnatal history), clinical characteristics, reasons for hospital admission, and indications for NICU or PICU care. We also recorded details of each cardiac arrest: type, cause, and location (operating room, ED, inpatient ward, NICU, or PICU), as well as the electrocardiography rhythm at arrest [bradycardia, asystole, PEA, or pulseless ventricular tachycardia/fibrillation (VT/VF)]. Resuscitation details were reviewed, including CPR duration (time from collapse to ROSC or death), medications

administered, procedures performed, and outcomes. Finally, we assessed achievement of ROSC, mortality, 28-day survival, and incidence of new organ failure following ROSC.

Study Outcomes

The primary outcome was ROSC, defined as the return of a palpable pulse with sustained circulation for at least 20 minutes. Secondary outcomes included survival to hospital discharge and survival rates at 28 days; identification of common factors leading to hospital or PICU admission that precipitated cardiac arrest; survival stratified by initial cardiac rhythm; and the incidence of new organ failure post-ROSC, along with its impact on survival.

Definitions

The cardiac arrest phase is defined as the duration from the cardiac arrest onset to the initiation of effective CPR. Therefore, prompt identification of worsening conditions by rapid response teams is essential for effective intervention.[23,24] CPR is defined as the administration of chest compressions and assisted ventilation in response to cardiac arrest or significant bradycardia accompanied by inadequate perfusion.[25] The post-resuscitation phase is defined as the critical period after ROSC, necessitating rigorous monitoring for complications, including multi-organ failure and other adverse outcomes. Multi-organ failure is defined as the dysfunction of two or more organ systems, resulting in an inability to maintain spontaneous activity.

Statistical Analysis

The data analysis of the current research was performed using SPSS version 26.0 (IBM Corp., Armonk, NY). Normality evaluations of continuous variables were conducted through the Shapiro-Wilk test, and these variables were reported as the median and interquartile range (IQR), while categorical data were presented as frequencies and percentages. Comparative analyses were performed through the Mann-Whitney U test to compare CPR duration between two groups, whereas the Kruskal-Wallis test facilitated comparisons between more groups. Pairwise comparisons were conducted using the Bonferroni correction, and chi-square and Fisher's exact tests were employed to compare proportions across categorical groups. Furthermore, receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic capability of CPR duration in predicting ROSC achievement/non-achievement. In multivariate logistic regression, variables significant in bivariate analysis ($p<0.05$) were included in the models to determine independent predictors of ROSC achievement and 28-day survival. All subsequent tests were conducted at a $p<0.05$ significance level.

Results

Demographic and Clinical Characteristics

The research included 365 pediatric patients who experienced IHCA between 2013 and 2022. The median age of the patients was 6 months (IQR: 1 to 36 months), with 55.1% of the population being male. In accordance with participant demographics, age and gender did not correlate with ROSC achievement.

Location of First Cardiac Arrest

Patients with arrests in the emergency room (ER) showed significantly lower ROSC rates ($p=0.001$) compared to patients whose arrests occurred in PICUs, NICUs, wards, or operating rooms, as shown in Table 1. This may be related to the nature of most ER settings, which affect the resuscitation process as they are often over-stressed and resource limited.

Rhythm at the Time of Arrest

Cardiac rhythm, at the time of arrest, showed a stronger association with ROSC outcomes. Most patients with bradycardia showed poor perfusion (69%), followed by asystole (16.7%), PEA (10.1%), and pulseless VT/VF (4.1%). Patients with bradycardia showed better outcomes ($p=0.031$) in comparison to patients with asystole ($p=0.003$), as shown in Table 1.

CPR Duration and ROSC

Approximately 46% of patients did not achieve ROSC after the first cardiac arrest, with a 25.2% survival rate after 28 days. The CPR duration significantly correlated with the achievement of ROSC. The median CPR duration was 7 minutes (IQR: 4-15 minutes) among patients who achieved ROSC, as compared to a median CPR duration of 27 minutes (IQR: 20-44 minutes) among patients who did not achieve ROSC ($p<0.001$). Shorter CPR durations showed a stronger association with better outcomes, as indicated by the ROC curve analysis. ROC curve analysis showed that CPR duration of more than 15 minutes is a strong predictor of non-ROSC, with 0.866 [95% confidence interval (CI): 0.827-0.899] area under the curve at 82.0% accuracy, 87.0% sensitivity, 77.2% specificity, and $p<0.001$, as shown in Tables 2 and 3 and Figures 1 and 2.

Post-ROSC Organ Failure

After ROSC from the first cardiac arrest, the most common new organ failure was cardiovascular (18.8%), followed by respiratory (16.2%). However, no significant association was reported between CPR duration and the occurrence of new organ failure post-ROSC ($p>0.05$). This unexpected result may be influenced by factors not fully accounted for in this study, such as variations

Table 1. Association between patient's characteristics of studied patients with cardiac arrest 2013-2022 and achievement of ROSC

Variables	Total (n=365)	Achieving ROSC (n=197; 54%)	Not achieving ROSC (n=168; 56%)	p-value
Age (months): median (IQR)	6.0 months (1-36)	6.0 months (2-36)	4.50 months (1-36)	0.185
Gender				
Male	201 (55.1%)	108 (54.8%)	93 (55.4%)	0.918
Female	164 (44.9%)	89 (45.2%)	75 (44.6%)	
Preterm or full term				
Term	282 (77.3%)	150 (76.1%)	132 (78.6%)	0.581
Preterm	83 (22.7%)	47 (23.9%)	36 (21.4%)	
Location of first cardiac arrest				0.009
ICU	246 (67.4%)	135 (68.5%)	111 (66.1%)	0.617
NICU	71 (19.5%)	44 (22.3%)	27 (16.1%)	0.168
ER	32 (8.8%)	8 (4.1%)	24 (14.3%)	0.001
Ward	12 (3.3%)	7 (3.6%)	5 (3.0%)	0.995
Operation room	4 (1.1%)	3 (1.5%)	1 (0.6%)	0.747
Cause of hospital admission				
Cardiac	173 (47.4%)	89 (45.2%)	84 (50.0%)	0.358
Respiratory	103 (28.2%)	59 (29.9%)	44 (26.2%)	0.426
Prematurity	61 (16.7%)	36 (18.3%)	25 (14.9%)	0.386
Hematology/oncology	48 (13.2%)	31 (15.7%)	17 (10.1%)	0.113
GIT	45 (12.3%)	27 (13.7%)	18 (10.7%)	0.386
Neurological	33 (9.0%)	21 (10.7%)	12 (7.1%)	0.243
Sepsis	2 (0.5%)	1 (0.5%)	1 (0.6%)	0.999
Cause of ICU admission				
Post operative	113 (31.0%)	65 (33.0%)	48 (28.6%)	0.362
Respiratory failure	112 (30.7%)	59 (29.9%)	53 (31.5%)	0.741
Shock	82 (22.5%)	45 (22.8%)	37 (22.0%)	0.852
Prematurity	46 (12.6%)	28 (14.2%)	18 (10.7%)	0.315
Arrythmia	25 (6.8%)	17 (8.6%)	8 (4.8%)	0.145
Sepsis	15 (4.1%)	9 (4.6%)	6 (3.6%)	0.632
Convulsion	6 (1.6%)	2 (1.0%)	4 (2.4%)	0.420
Organ system affected before first cardiac arrest				
Cardiovascular	207 (56.7%)	108 (54.8%)	99 (58.9%)	0.430
Respiratory	121 (33.2%)	72 (36.5%)	49 (29.2%)	0.135
Neurological	69 (18.9%)	40 (20.3%)	29 (17.3%)	0.459
Hepatic	67 (18.4%)	40 (20.3%)	27 (16.1%)	0.298
Renal	48 (13.2%)	29 (14.7%)	19 (11.3%)	0.336
Sepsis	27 (7.4%)	16 (8.1%)	11 (6.5%)	0.567
Rhythm at time of first arrest				0.017
Brady with poor perfusion	252 (69.0%)	146 (74.1%)	106 (63.1%)	0.031
Asystole	61 (16.7%)	22 (11.2%)	39 (23.2%)	0.003
PEA	37 (10.1%)	22 (11.2%)	15 (8.9%)	0.596
Pulseless VT or VF+	15 (4.1%)	7 (3.6%)	8 (4.8%)	0.562
Duration of CPR in minutes				
Median (IQR)	18.0 minutes (7.0-30.0)	7.0 minutes (4.0-15.0)	27.0 minutes (20.0-40.0)	<0.001

ROSC: Return of spontaneous circulation, IQR: Interquartile range, ICU: Intensive care unit, NICU: Neonatal intensive care unit, ER: Emergency room, GIT: Gastrointestinal tract, PEA: Pulseless electric activity, VT: Ventricular tachycardia, VF+: Ventricular fibrillation

in pre-existing conditions, ICU management strategies, or sample size limitations. Additionally, this study did not perform a separate analysis of individual organ systems, which may have masked potential relationships between CPR duration and specific types of organ dysfunction. Future research should examine each organ system separately to better understand how resuscitation efforts influence post-ROSC outcomes.

Survival Beyond 28 Days

In the current study, the survival rate after 28 days was 25.2%. The median age was 4 months (IQR: 3-36) in the survival group, as compared to 8 months (IQR: 1-36) in the non-survival group (p=0.031). The median CPR duration for patients surviving more than 28 days was 5 minutes, as compared to 20 minutes for patients who did not survive (p<0.001). Patients with primary arrest in ER and NICU showed the highest mortality rates (p=0.032 and p=0.036, respectively). Notably, PICU patients showed better survival rates (p=0.002). Furthermore, patients with hepatic failure and sepsis showed higher mortality rates (p=0.032 and p<0.001, respectively), as shown in Table 4.

Table 2. Diagnostic criteria for duration of CPR in prediction of not achieving ROSC

Validity measures	Diagnostic criteria Duration of CPR
AUC (95% CI)	0.866 (0.827-0.899)
Cut-off	>15.0 min
Accuracy %	82.0%
Sensitivity %	87.0%
Specificity %	77.2%
PPV^{+} %	76.4%
NPV$^{\wedge}$ %	87.4%
p-value	<0.001

CPR: Cardiopulmonary resuscitation, ROSC: Return of spontaneous circulation, AUC: Area under the curve, CI: Confidence interval, PPV^{+}: Positive predictive value, NPV$^{\wedge}$: Negative predictive value

Table 3. Comparison between duration of CPR and achievement of ROSC

Outcome	Duration of CPR in first arrest Median (IQR)
Not achieved ROSC (n=168, 46.0%)	27.0 minutes (20.0-40.0)
Less than 24-h survival (n=64, 17.5%)	10.0 minutes (5.0-15.0)*
Less than 5-day survival (n=17, 4.7%)	10.0 minutes (5.0-40.0)*
Less than 28-day survival (n=24, 6.6%)	6.0 minutes (3.0-20.0)*
More than 28-day survival (n=92, 25.2%)	5.0 minutes (3.0-13.0)*
p^{+}	<0.001

CPR: Cardiopulmonary resuscitation, ROSC: Return of spontaneous circulation, IQR: Interquartile range, *: Significant in comparison to not achieving ROSC group by Pairwise comparison with Bonferroni correction, $^{+}$: Kruskal-Wallis test compares median duration between groups

Multivariate Logistic Regression Analysis

Multivariate logistic regression analysis was performed to identify independent predictors of both return of ROSC and 28-day survival. For ROSC, the analysis revealed that ER arrests (OR=4.12, 95% CI: 1.49-11.41, p=0.006) and increased CPR duration (OR=1.11 per minute, 95% CI: 1.08-1.14, p<0.001) were significantly associated with failure to achieve ROSC.

For 28-day survival, prolonged CPR duration remained a significant predictor of poor outcomes (OR=1.11, 95% CI: 1.07-1.14, p<0.001). Conversely, in the case of post-operative conditions (OR=0.27, 95% CI: 0.14-0.52, p<0.001) or arrhythmia (OR=0.21, 95% CI: 0.06-0.61, p=0.005) as

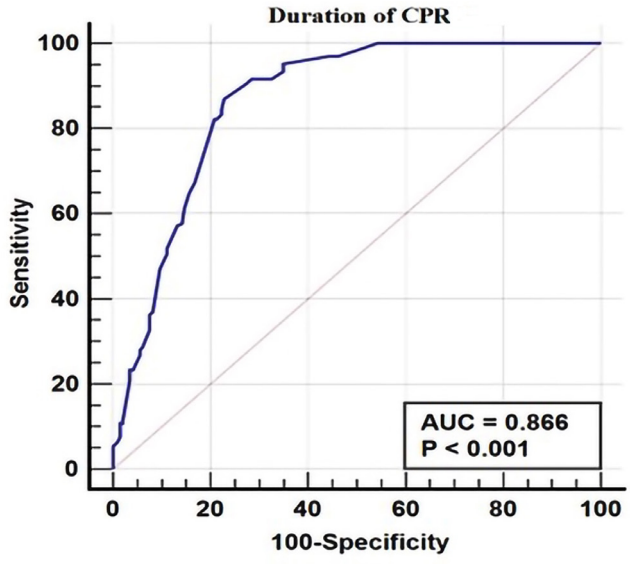

Figure 1. ROC curve for the ability of duration of CPR in the prediction of not achieving ROSC
ROC: Receiver operating characteristic, ROSC: Return of spontaneous circulation, CPR: Cardiopulmonary resuscitation, AUC: Area under the curve

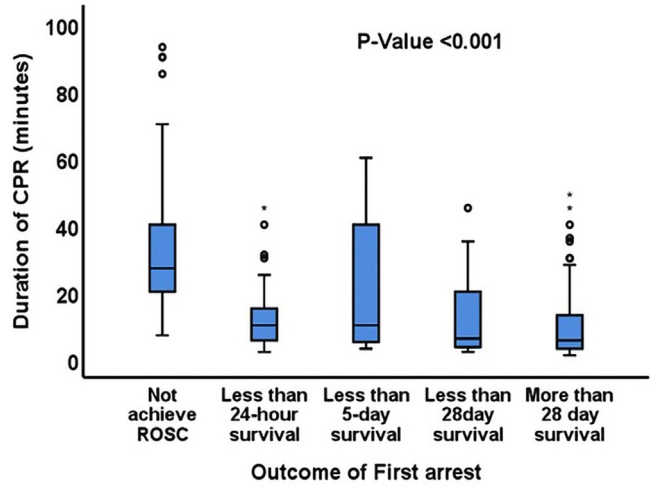

Figure 2. Boxplot for the CPR duration according to arrest outcome
ROSC: Return of spontaneous circulation, CPR: Cardiopulmonary resuscitation

Table 4. Association between patient's characteristics of studied patients with cardiac arrest 2013-2022 and mortality

Variables	>28 days survival (n=92)	Died (n=273)	p-value*
Age (months): median (IQR)	8.0 months (3-36)	4.00 months (1-36)	0.031
Gender			
Male	49 (53.3%)	152 (55.7%)	0.687
Female	43 (46.7%)	121 (44.3%)	
Preterm or full term			
Term	75 (81.5%)	207 (75.8%)	0.275
Preterm	17 (18.5%)	66 (24.2%)	
Location of first cardiac arrest			0.028
PICU	74 (80.4%)	172 (63.0%)	0.002
NICU	11 (12.0%)	60 (22.0%)	0.036
ER	3 (3.3%)	29 (10.6%)	0.032
Ward	3 (3.3%)	9 (3.3%)	0.999
Operation room	1 (1.1%)	3 (1.1%)	0.999
Cause of hospital admission			
Cardiac	50 (54.3%)	123 (45.1%)	0.123
Respiratory	26 (28.3%)	77 (28.2%)	0.992
Prematurity	12 (13.0%)	49 (17.9%)	0.275
Hematology/oncology	9 (9.8%)	39 (14.3%)	0.269
GIT	13 (14.1%)	32 (11.7%)	0.543
Neurological	10 (10.9%)	23 (8.4%)	0.479
Sepsis	0 (0.0%)	2 (0.7%)	0.410
Cause of PICU admission			
Post operative	46 (50.0%)	67 (24.5%)	<0.001
Respiratory failure	23 (25.0%)	89 (32.6%)	0.172
Shock	14 (15.2%)	68 (24.9%)	0.054
Prematurity	9 (9.8%)	37 (13.6%)	0.346
Arrythmia	11 (12.0%)	14 (5.1%)	0.025
Sepsis	1 (1.1%)	14 (5.1%)	0.128
Convulsion	1 (1.1%)	5 (1.8%)	0.999
Organ system affected before first cardiac arrest			
Cardiovascular	58 (63.0%)	149 (54.6%)	0.156
Respiratory	26 (28.3%)	95 (34.8%)	0.249
Neurological	19 (20.7%)	50 (18.3%)	0.620
Hepatic	10 (10.9%)	57 (20.9%)	0.032
Renal	14 (15.2%)	34 (12.5%)	0.498
Sepsis	0 (0.0%)	27 (9.9%)	<0.001
Rhythm at time of first arrest			
Bradycardia with poor perfusion	62 (67.4%)	190 (69.6%)	0.692
Asystole	12 (13.0%)	49 (17.9%)	0.275
PEA+	16 (17.4%)	21 (7.7%)	0.008
Pulseless VT or VF	2 (2.2%)	13 (4.8%)	0.279
Duration of CPR in minutes			
Median (IQR)	5.0 minutes (3.0-13.0)	20.0 minutes (10.0-32.5)	<0.001

*: Chi-square/Fisher's exact tests compare proportions between groups, PICU: Pediatric intensive care unit, NICU: Neonatal intensive care unit, ER: Emergency room, GIT: Gastrointestinal tract, PEA+: Pulseless electric activity, VT: Ventricular tachycardia, VF: Ventricular fibrillation, IQR: Interquartile range

the cause of PICU admission, the results showed a higher association with improved odds of survival, as shown in Table 5.

Discussion

The study evaluated the interplay between CPR duration, initial presenting cardiac rhythm, and arrest location on survival outcomes in pediatric IHCA over ten years. The findings underscore the pivotal role of timely, effective resuscitation in this vulnerable population and highlight the need to enhance both resuscitation and post-resuscitation care. Prolonged CPR duration was significantly associated with poorer outcomes, including lower rates of return of ROSC and reduced 28-day survival. These results align with prior studies demonstrating the critical impact of resuscitation quality on pediatric IHCA outcomes.[19-21]

The findings do not show a significant relation between prolonged CPR and post-ROSC organ failure. This contradicts published data in adults, which may be related to different physiological responses and varied age-specific management protocols.[2] However, other factors may play an essential role, such as pre-existing clinical conditions and the quality of post-arrest care. According to Mally et al.[25] the location of arrests appears to be a significant factor influencing outcomes, as arrests in ER exhibited worsened outcomes in comparison to arrests in specialized units such as NICUs and PICUs.[14] This difference emphasizes the distinctive challenges encountered in resource-limited ERs and reinforces the necessity of protocol optimization alongside the allocation of resources within such environments.[8,14] Conversely, the results showed no significant correlation between younger age and ROSC, contradicting previous research findings that showed an association between younger age and increased mortality.[8]

The outcomes of this research align with current literature;[3,12,13,20] the initial cardiac rhythm correlated with the research outcomes. Bradycardia with poor perfusion exhibited more favorable outcomes than asystole, highlighting the value of rhythm evaluation and targeted measures.

This highlights the necessity of enhancing healthcare infrastructure in anticipation of possible future worldwide disasters.[3,8,20,26] The 28-day survival rate of 25.2% aligns with previous studies, underscoring the significant effectiveness of the post-ROSC phase in specialized care environments such as NICUs and PICUs.[8,20,26,27] Thus, it highlights the crucial role of targeted interventions and post-resuscitation strategies.[28]

Table 5. Multivariate logistic regression analysis

Factors associated with not achieving ROSC return of spontaneous circulation (ROSC)				
	OR	**95% CI**		**p-value**
		Lower	**Upper**	
Age in months	1.00	0.99	1.01	0.917
Location of first cardiac arrest at ER	4.12	1.49	11.41	0.006
Rhythm at time of first arrest				
Asystole	1.45	0.54	3.87	0.453
Bradycardia with poor perfusion	1.03	0.47	2.26	0.940
Duration of CPR in first arrest to achieve ROSC in minutes	1.11	1.08	1.14	<0.001
Factors associated with less than 28 days mortality				
Age in months	1.002	0.99	1.01	0.667
Location of first cardiac arrest				
At emergency room	2.41	0.37	15.50	0.352
At ICU	0.89	0.22	3.61	0.881
At NICU	1.91	0.40	9.01	0.411
Cause of PICU admission				
Post operative	0.27	0.14	0.52	<0.001
Shock	1.97	0.92	4.21	0.080
Arrythmia	0.21	0.06	0.61	0.005
Duration of CPR in first arrest to achieve ROSC in minutes	1.11	1.07	1.14	<0.001
Organ system affected before first cardiac arrest				
Hepatic	1.74	0.28	10.77	0.548

OR: Odds ratio, CI: Confidence interval, dependent variable: less than 28 days mortality, ROSC: Return of spontaneous circulation, ER: Emergency room, CPR: Cardiopulmonary resuscitation, ICU: Intensive care unit, NICU: Neonatal intensive care unit, PICU: Pediatric intensive care unit

The current research highlights numerous clinically actionable targets, such as shortening CPR duration, especially in ER environments. Enhanced team collaboration, continuous uninterrupted chest compressions, and prompt resource access are vital. Furthermore, identifying initial cardiac rhythms and executing rhythm-specific actions are necessary for improving outcomes. The multivariate analysis in the current study revealed significant predictors of pediatric IHCA clinical outcomes. Arrests in ER were significantly correlated with ROSC failure (OR=4.12), aligning with the results of Mally et al.[25] Also, prolonged CPR duration significantly correlated with 28-day survival and ROSC (OR=1.11 per minute duration), indicating the value of timely interventions.[8] Multivariate regression indicated that longer CPR duration was statistically related to reduced ROSC rates and reduced 28-day survival. However, this relationship does not necessarily indicate a direct cause-and-effect relationship. Instead, longer CPR may serve as a marker of the severity of underlying diseases and not an independent predictor for poor outcomes. This is consistent with previous studies indicating that longer CPR duration tends to be a marker of increased illness severity rather than a direct cause of poor outcomes.[29] As a result, multivariate logistic regression was performed in the study, controlling important variables, including the initial cardiac arrest rhythm, site of arrest, and reason for PICU admission (Table 5). The findings suggested that although CPR time continued to be significantly related to ROSC and survival, other clinical variables, including the presenting arrest rhythm and site of the event, also contributed significantly to outcomes.

Better ROSC odds were noted in arrests caused by arrhythmias and in post-operative patients admitted to ICUs, implying possible underlying protective mechanisms. The 28-day survival rate in the current study conforms to the trends reported by Kienzle et al.[27] highlighting the necessity of tailored and optimized post-ROSC care. However, the results offer a solid basis for future studies that could incorporate a multi-center research design and integrate further evaluation of targeted interventions to improve CPR quality and duration, especially across ER environments, while further exploring the interaction between factors that influence long-term survival rates and post-arrest quality of life.

Study Limitations

The retrospective design of this study restricts the researcher from establishing a causal relationship between CPR time, initial cardiac rhythm, and IHCA survival outcomes. Furthermore, although the overall sample size of 365 children is large, the statistical power for subgroup analyses, especially comparisons between various arrest types and resuscitation environments (PICU vs. NICU), is still limited. As the study was conducted at a single center, future multicenter studies could improve generalizability.

Conclusion

This study sheds light on key determinants of outcomes in IHCA, addressing significant gaps in existing literature. The research findings emphasize the critical influence of CPR duration, initial cardiac rhythm, and arrest location on both immediate and short-term survival, thus highlighting the pressing need for refined resuscitation strategies, particularly in high-risk scenarios such as ER arrests and cases that require extended CPR. The observed rhythm-specific variations in outcomes reinforce the necessity of tailored, rhythm-focused interventions. The analysis of 28-day survival rates underscores ongoing challenges and the imperative need for improved post-resuscitation care. These insights serve as a robust foundation for developing targeted protocols aimed at enhancing outcomes in pediatric IHCA.

Ethics

Ethics Committee Approval: The Institutional Review Board approved the study protocol at King Faisal Specialist Hospital & Research Center, Jeddah, Saudi Arabia (approval number: IRB 2032-82, date: 21.07.2023).

Informed Consent: Informed consent was waived for this research due to the retrospective nature of the studies.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.Y., M.H., A.G., H.A., A.A., Concept: A.Y., M.H., A.G., H.A., A.A., Design: A.Y., M.H., A.G., H.A., A.A., Data Collection or Processing: A.Y., M.H., A.G., H.A., A.A., Analysis or Interpretation: A.Y., M.H., A.A., Literature Search: A.Y., M.H., A.G., H.A., A.A., Writing: A.Y., A.A.

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References

1. Sirbaugh PE, Pepe PE, Shook JE, Kimball KT, Goldman MJ, et al. A prospective, population-based study of the demographics, epidemiology, management, and outcome of out-of-hospital pediatric cardiopulmonary arrest. Ann Emerg Med. 1999;33:174-84.
2. Sakai-Bizmark R, Friedlander SMI, Marr EH, Mena LA, Corral I, et al. Patient characteristics and emergency department factors associated with survival after sudden cardiac arrest in children and young adults: a cross-sectional analysis of a nationally representative sample, 2006-2013. Pediatr Cardiol. 2018;39:1216-28.
3. Morgan RW, Kirschen MP, Kilbaugh TJ, Sutton RM, Topjian AA. Pediatric in-hospital cardiac arrest and cardiopulmonary

resuscitation in the United States: a review. JAMA Pediatrics. 2021;175:293-302.

4. Seewald S, Wnent J, Lefering R, Fischer M, Bohn A, et al. Cardiac arrest survival score (CRASS) - a tool to predict good neurological outcome after out-of-hospital cardiac arrest. Resuscitation. 2020;146:66-73.
5. Ebell MH, Jang W, Shen Y, Geocadin RG. Get with the guidelines–resuscitation investigators. Development and validation of the good outcome following attempted resuscitation (GO-FAR) score to predict neurologically intact survival after in-hospital cardiopulmonary resuscitation. JAMA Intern Med. 2013;173:1872-8.
6. Magid DJ, Aziz K, Cheng A, Hazinski MF, Hoover AV, et al. Part 2: evidence evaluation and guidelines development: 2020 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2020;142(16_suppl_2):S358-65.
7. Andersen LW, Raymond TT, Berg RA, Nadkarni VM, Grossestreuer AV, et al. American Heart Association's get with the guidelines-resuscitation investigators. Association between tracheal intubation during pediatric in-hospital cardiac arrest and survival. JAMA. 2016;316:1786-97.
8. Matos RI, Watson RS, Nadkarni VM, Huang HH, Berg RA, et al. American Heart Association's get with the guidelines-resuscitation (formerly the national registry of cardiopulmonary resuscitation) investigators. Duration of cardiopulmonary resuscitation and illness category impact survival and neurologic outcomes for in-hospital pediatric cardiac arrests. Circulation. 2013;127:442-51.
9. Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, et al. Adult basic and advanced life support writing group. Part 3: adult basic and advanced life support: 2020 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2020;142(16_suppl_2):S366-468.
10. Khera R, Tang Y, Girotra S, Nadkarni VM, Link MS, et al. American Heart Association's get with the guidelines-resuscitation investigators. Pulselessness after initiation of cardiopulmonary resuscitation for bradycardia in hospitalized children. Circulation. 2019;140:370-8.
11. Holmberg MJ, Wiberg S, Ross CE, Kleinman M, Hoeyer-Nielsen AK, et al. Trends in survival after pediatric in-hospital cardiac arrest in the United States. Circulation. 2019;140:1398-408.
12. Nadkarni VM, Larkin GL, Peberdy MA, Carey SM, Kaye W, et al. National registry of cardiopulmonary resuscitation investigators. First documented rhythm and clinical outcome from in-hospital cardiac arrest among children and adults. JAMA. 2006;295:50-7.
13. Abella BS, Alvarado JP, Myklebust H, Edelson DP, Barry A, et al. Quality of cardiopulmonary resuscitation during in-hospital cardiac arrest. JAMA. 2005;293:305-10.
14. Söğütlü Y, Altaş U. Pediatric In-hospital cardiac arrest: an examination of resuscitation outcomes. Medicina (Kaunas). 2024;60:1739.
15. Kienzle MF, Morgan RW, Faerber JA, Graham K, Katcoff H, et al. The effect of epinephrine dosing intervals on outcomes from pediatric in-hospital cardiac arrest. Am J Respir Crit Care Med. 2021;204:977-85.
16. Moler FW, Meert K, Donaldson AE, Nadkarni V, Brilli RJ, et al. Pediatric Emergency Care Applied Research Network. In-hospital versus out-of-hospital pediatric cardiac arrest: a multicenter cohort study. Crit Care Med. 2009;37:2259-67.
17. O'Halloran A, Morgan RW, Kennedy K, Berg RA, Gathers CA, et al. American Heart Association's get with the guidelines-resuscitation investigators. Characteristics of pediatric in-hospital cardiac arrests and resuscitation duration. JAMA Netw Open. 2024;7:e2424670.
18. Brown SR, Frazier M, Roberts J, Wolfe H, Tegtmeyer K, et al. PediRES-Q Collaborative Investigators. CPR quality and outcomes after extracorporeal life support for pediatric in-hospital cardiac arrest. Resuscitation. 2023;189:109874.
19. Del Castillo J, Sanz D, Herrera L, López-Herce J; Grupo de Estudio de Parada Cardiaca Intrahospitalaria en la Infancia. Pediatric in-hospital cardiac arrest international registry (PACHIN): protocol for a prospective international multicenter register of cardiac arrest in children. BMC Cardiovasc Disord. 2021;21:365.
20. Raza A, Arslan A, Ali Z, Patel R. How long should we run the code? Survival analysis based on location and duration of cardiopulmonary resuscitation (CPR) after in-hospital cardiac arrest. J Community Hosp Intern Med Perspect. 2021;11:206-11.
21. Andersen LW, Berg KM, Saindon BZ, Massaro JM, Raymond TT, et al. American Heart Association get with the guidelines–resuscitation investigators. Time to epinephrine and survival after pediatric in-hospital cardiac arrest. JAMA. 2015;314:802-10.
22. Otto CM, Nishimura RA, Bonow RO, Carabello BA, Erwin JP 3rd, et al. 2020 ACC/AHA Guideline for the management of patients with valvular heart disease: executive summary: a report of the American College of Cardiology/American Heart Association Joint Committee on clinical practice guidelines. Circulation. 2021;143:e35-71.
23. Patel K, Hipskind JE. Cardiac arrest. 2023 Apr 7. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025.
24. Olasveengen TM, Mancini ME, Perkins GD, Avis S, Brooks S, et al. Adult basic life support collaborators. Adult basic life support: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with treatment recommendations. Circulation. 2020;142(16_suppl_1):S41-91.
25. Mally D, Namazzi R, Musoke P, Munube D, Luggya TS, et al. Outcomes of pediatric in-hospital cardiac arrest in the emergency department of a tertiary referral hospital in Tanzania: a retrospective cohort study. BMC Emerg Med. 2024;24:178.
26. Bae G, Eun SH, Yoon SH, Kim HJ, Kim HR, et al. Mortality after cardiac arrest in children less than 2 years: relevant factors. Pediatr Res. 2024;95:200-4.
27. Kienzle MF, Morgan RW, Reeder RW, Ahmed T, Berg RA, et al. Epinephrine dosing intervals are associated with pediatric in-hospital cardiac arrest outcomes: a multicenter study. Crit Care Med. 2024;52:1344-55.
28. Freedman AJ, Madsen EC, Lowrie L. Establishing a quality improvement program for pediatric in-hospital cardiac arrest. Pediatr Qual Saf. 2023;8:e706.
29. Committee on the Treatment of Cardiac Arrest: Current Status and Future Directions; Board on Health Sciences Policy; Institute of Medicine. Strategies to improve cardiac arrest survival: a time to act. Graham R, McCoy MA, Schultz AM, editors. Washington (DC): National Academies Press (US); 2015.