

Outcomes of Pediatric Cardiopulmonary Resuscitation: A Retrospective Cross-Sectional Study from a Single Center

Rola S Saqan¹, Liqaa A Raffee², Khaled J Zaitoun³, Ghena Zaitoun⁴, Salam Omar Tahtamoni², Khaled Zayed Alawneh⁵, Retaj K Alawneh³, Murad A Yasawy², Rami AlAzab⁶

¹Department of Pediatrics, Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan; ²Department of Accident and Emergency Medicine, Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan; ³Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan; ⁴Department of Biology, Edmonds Community College, Lynnwood, WA, USA; ⁵Department of Diagnostic Radiology & Nuclear Medicine, Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan; ⁶Department of General Surgery and Urology, Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan

Correspondence: Rola S Saqan, Department of Paediatrics, Faculty of Medicine, Jordan University of Science and Technology, P.O. Box 3030, Irbid, 22110, Jordan, Tel +962799051209, Email rssaqaan@just.edu.jo; Khaled J Zaitoun, Faculty of Medicine, Jordan University of Science and Technology, P.O. Box 3030, Irbid, 22110, Jordan, Tel +962798652961, Email kjzaitoun20@med.just.edu.jo

Introduction: Cardiac arrest is defined by a lack of central pulse, unresponsiveness, and apnea, indicating the termination of effective mechanical heart activity. Although rare in pediatrics, it results in poor outcomes. Results concerning the survival rates of pediatrics after cardiopulmonary resuscitation (CPR) in Jordan are absent, making this study crucial knowledge for implication of hospital protocol.

Material/Method: A retrospective study was conducted at a tertiary hospital in Jordan. This study included 411 pediatric patients, aged over one day to under 12 years, who underwent CPR either during an emergency department (ED) visit or during hospitalization. The Mann–Whitney *U*-test, Chi-Square test, and Fisher's exact tests were used for analysis. Survival-associated factors were analyzed using univariate and multivariate logistic regression, and $p < 0.05$ was considered significant.

Results: Patients were separated into a less than one year age group and a greater than one year age group, with similar gender distributions. Survival was significantly associated with age; the survivors were older than the non-survivors. Furthermore, the presence of any neurological manifestation was associated with a higher risk of mortality with an odds ratio of 3.97 (95% CI: 1.46–10.86, $p = 0.007$). After adjusting for all covariates, each 1% rise in oxygen saturation increased the adjusted odds ratio (AOR) of survival (AOR = 1.08, 95% CI 1.01–1.15; $p = 0.031$). In the same model, every additional minute of CPR sharply decreased the likelihood of survival (AOR = 0.38, 95% CI 0.21–0.72; $p = 0.003$).

Conclusion: The survival rates after CPR in pediatrics were poor overall, suggesting a need for better pediatric CPR strategies and further studies. Many factors could affect the outcomes, most importantly, the duration of CPR and the oxygen saturation.

Keywords: pediatric patients, cardiopulmonary resuscitation, emergency department, retrospective study

Introduction

Cardiac arrest is a medical condition characterized by a lack of central pulse, unresponsiveness, and apnea, clinically indicating the termination of effective mechanical heart activity.¹ Cardiac arrests are rare in the pediatric age group and, generally, poor outcomes are evident in pediatric patients. The out-of-hospital incidence rate of cardiac arrests in the pediatric age range is unknown; however, cardiac arrest within intensive care units is thought to occur 0.94 times per 100 admissions.²

Outcomes vary according to whether the cardiac arrest has a respiratory or cardiac cause, and whether it occurs in the emergency department (ED) or in-hospital stay.³ Moreover, identifying the early causes of pediatric cardiac arrest can

allow physicians in both EDs and in-hospital to properly manage the situation and prevent the arrest from taking place.⁴ Respiratory failure leading to circulatory collapse is the main cause of cardiac arrests.⁵

In general, the survival rate of pediatric patients who suffer a cardiac arrest is low, less than half of the patients that survived were discharged from the hospital, and, among the survivors, most suffered severe neurological complications.^{3,5,6} Although, timely recognition of at-risk patients and high-quality cardiopulmonary resuscitation (CPR) improved outcomes.⁷

Early identification of cardiac rhythm, proper chest compression without interruptions, and early recognition of reversible causes of cardiac arrest are all factors associated with high rates of survival.⁸ Similarly, good management of post-cardiac arrest can lead to improved neurological outcomes and increased survival rates.⁷ Likewise, factors associated with in-hospital cardiac arrest in pediatrics elective admissions had better outcomes compared to ED admissions. Additionally, teaching hospitals had higher rates of survival compared to non-teaching hospitals.⁹ Moreover, the greater the number of CPR cycles/duration, the higher the incidence of survival.¹⁰

Hemodynamically unstable patients are common victims of post-cardiac arrest. Also, multiorgan failure led to death and was associated with a low cardiac index in the first 24 hours after resuscitation. Furthermore, vasodilation occurs due to sympathetic tone loss from metabolic acidosis.¹¹ Administration of fluid along with vasoactive (eg, norepinephrine) and inotropic (eg, dobutamine) agents should be titrated as needed to optimize blood pressure, cardiac output, and systemic perfusion. Although mechanical circulatory support improves hemodynamics in patients not experiencing cardiac arrest, it has not been associated with improved clinical outcome and routine use of mechanical circulatory support after cardiac arrest and is not recommended.¹²

Results concerning the survival rates after CPR in the pediatric age group in Jordan are absent, making this study essential for knowledge of these survival rates and the possible effects on hospital protocol. Despite that, we expect overall results to have poor outcomes and low survival rates, comparable to global studies. In this study, we focused on pediatric patients who underwent CPR in both ED and in-hospital stay. Where we aim to investigate the relationship between survival rates and various factors, with a particular focus on older age. The hypothesis is that, in cardiac arrest, survival is positively correlated with older age, higher median oxygen saturation, and shorter duration of CPR.

Methodology

Study Cohort

A retrospective study was conducted in King Abdullah University Hospital (KAUH) that examined 411 cases. This study included the data of patients who were admitted into the hospital and ED between 2017 and 2022. The inclusion criteria of the study involved recruiting pediatric patients greater than one day and less than 12 years of age who underwent CPR during both ED visits and in-hospital stays.

Ethical approval was obtained from the ethical committee in the Institutional Review Board (IRB) of Jordan University of Science and Technology (JUST); Reference number: 30/152/2022.

Data Collection

Data was collected through electronic medical records ie gender, age, height, weight, underlying congenital diseases, prematurity, with whom patients arrived at the hospital (family, civil defence and public), location of arrest (Hospital vs others), patient resuscitation before or after hospital entry, type of cardiac rhythm, duration of CPR by minutes, use of medications during CPR, neurological manifestation, heart rate (HR), respiratory rate (RR), oxygen saturation (SpO₂), hospital course, and survival after CPR.

Congenital diseases were defined as any structural, chromosomal, or metabolic anomaly present at birth. Structural defects included congenital heart malformations (ventricular septal defect, atrial septal defect, tetralogy of fallot, transposition of the great arteries, hypoplastic left heart syndrome), neural tube defects (spina bifida, myelomeningocele), pulmonary anomalies (pulmonary hypoplasia, congenital diaphragmatic hernia), and gastrointestinal malformations (esophageal atresia, tracheoesophageal fistula). Chromosomal syndromes included Down syndrome and Patau syndrome. Endocrine disorders included congenital adrenal hyperplasia. Metabolic disorders included mitochondrial disorders and

severe combined immunodeficiency. Whereas, neurological manifestations were defined as any acute neurological sign documented at the time of cardiac arrest, including seizures, reduced level of consciousness, hypotonia, or focal neurological deficits.

Cardiac rhythms associated with cardiac arrest were classified as non-shockable (asystole or pulseless electrical activity) or shockable (ventricular fibrillation or pulseless ventricular tachycardia).^{13,14} Epinephrine (0.01 mg/kg IV/IO every 3–5 min) was the first-line agent—used alone in the majority of medicated CPRs or combined with other therapies—while dopamine (2–20 µg/kg/min), dobutamine (5–10 µg/kg/min), hydrocortisone (2 mg/kg), magnesium sulfate (25–50 mg/kg), and blood products (FFP 10–15 mL/kg) were given in the remaining cases per clinical indication.

Out-of-hospital cardiac arrest was defined as any arrest that occurred before the patient reached the ED, including cases in which chest compressions were still in progress on arrival. In-hospital cardiac arrest was defined as an arrest that occurred after the patient had already been registered in the ED or admitted to any hospital ward.

For SpO₂, HR, and RR, we extracted the last monitor value recorded ≤5 min before loss of pulse in in-hospital arrests, or the first ED triage value (before CPR was resumed) in out-of-hospital arrests.

Statistical Analysis

The data analysis was performed using IBM SPSS Software version 26.0. The normality of the data was evaluated using graphical methods, including histograms and Q-Q plots, along with formal statistical tests such as the Kolmogorov–Smirnov and Shapiro–Wilk tests. These assessments indicated that none of the continuous variables followed a normal distribution. As a result, non-parametric tests, such as the Mann–Whitney *U*-test, were employed for subsequent analyses. Continuous variables were summarized using median (IQR). Categorical variables were presented as numbers (%) and analyzed using the Chi-square test for larger sample sizes and expected frequencies, or Fisher’s exact test when the sample size was small or expected frequencies were less than 5 in any cell.

Logistic regression in univariate and multivariate models was used to determine factors associated with survival. Variables with a $p < 0.10$ in univariate logistic regression were a candidate and included in multivariate logistic regression. In multivariate logistic regression, using the backward stepwise approach, variables having a $p < 0.05$ were considered statistically significant. Odds ratios (ORs) and their 95% confidence intervals (CIs) were reported for each variable.

Sample Size Calculation

At a level of confidence of 95%, level of significance of 0.05, and assuming that 50% of the study population are at risk of death, the sample size needed within a margin error of 5% was calculated at 385 patients.¹⁵ This calculation assumes a point-estimate mortality of 50% and yields a two-sided 95% confidence interval of 45–55% ($\alpha = 0.05$). However, all 411 cases available during the study period were included to maximize the statistical power and robustness of the results. In this retrospective cohort, the calculation is illustrative; the study’s interpretive strength lies in the observed effect sizes and their 95% confidence intervals.

Results

Descriptive Characteristics

Table 1 presents the median age as 0.5 (0.1, 3.0) months for the less than one year group and 44.0 (25.5, 81.8) months for the more than one year group. Gender distribution is similar, with 53.1% male in the less than one year group and 60.0% male in the more than one year group.

Prematurity is significantly higher in the less than one year group (33.6%) than in the more than one year group (2.1%) ($p < 0.001$). Congenital conditions are more common in the less than one year group (31.4%) compared to the more than one year group (17.9%) ($p = 0.003$). Whereas neurological conditions were higher in the more than one year group (27.1%) compared to the less than one year group (10.3%) ($p < 0.001$).

Most participants arrived with family: 94.8% in the less than one year group and 90.7% in the more than one year group ($p = 0.008$). Resuscitation before arrival was needed for 1.5% of the less than one year group and 10.7% of the more than one year group ($p < 0.001$).

Table 1 General Characteristics of Study Population

	Less Than One Year (N = 271)	More Than One Year (N = 140)	Total (N = 411)	p value
Age, months				–
Median (IQR)	0.5 (0.1, 3.0)	44.0 (25.5, 81.8)	3.0 (0.1, 29.5)	
Gender				0.185
Male	144.0 (53.1%)	84.0 (60.0%)	228.0 (55.5%)	
Female	127.0 (46.9%)	56.0 (40.0%)	183.0 (44.5%)	
Prematurity	91.0 (33.6%)	3.0 (2.1%)	94.0 (22.9%)	< 0.001
Height				–
Median (IQR)	47.0 (37.5, 55.0)	100.0 (83.0, 120.0)	58.0 (44.0, 92.0)	
Weight				–
Median (IQR)	2.2 (0.9, 3.4)	13.5 (10.0, 20.0)	3.3 (1.4, 10.0)	
Congenital disease	85.0 (31.4%)	25.0 (17.9%)	110.0 (26.8%)	0.003
Neurological manifestation	28.0 (10.3%)	38.0 (27.1%)	66.0 (16.1%)	< 0.001
Method of arrival to hospital				0.008
Family	257.0 (94.8%)	127.0 (90.7%)	384.0 (93.4%)	
Civilian defense	4.0 (1.5%)	13.0 (9.3%)	17.0 (4.1%)	
Referral from other departments/hospitals	10.0 (3.7%)	0.0 (0.0%)	10.0 (2.4%)	
Resuscitated before arrival*				< 0.001
Yes	4.0 (1.5%)	15.0 (10.7%)	19.0 (4.6%)	
No	267.0 (98.5%)	125.0 (89.3%)	392.0 (95.4%)	
Resuscitated after arrival				0.694
Yes	267.0 (98.5%)	137.0 (97.9%)	404.0 (98.3%)	
No	4.0 (1.5%)	3.0 (2.1%)	7.0 (1.7%)	

Notes: Bold indicates significance (at P value <0.05). *Any resuscitative intervention started in the field, whether or not the child was in cardiac arrest.

Factors Associated with the Chance of Survival

As shown in Table 2, increase in age in the less than one year group age was significantly associated with higher chance of survival; those who survived had a median (IQR) age of 7.0 (0.7, 9.2) months compared to a median of 0.4 (0.0, 2.4) months for those who did not ($p=0.004$). Although, the more than one year group showed higher rate of survival overall (9/262 vs 8/132, respectively).

Table 2 Factors Associated with the Chance of Survival

	Less Than One Year (N = 271)			More Than One Year (N = 140)		
	Survived N = 9	Died N = 262	P value	Survived N = 8	Died N = 132	P value
Age, months	7.0 (0.7, 9.2)	0.4 (0.0, 2.4)	0.004	36 (28, 42)	48 (26, 84)	0.116
Gender, male	7.0 (77.8%)	137.0 (52.3%)	0.180	6.0 (75.0%)	78.0 (59.1%)	0.476
Preterm	0.0 (0.0%)	91.0 (34.7%)	0.031	1.0 (12.5%)	2.0 (1.5%)	0.163
Received medication	3.0 (33.3%)	186.0 (71.0%)	0.024	5.0 (62.5%)	72.0 (54.5%)	0.730
Intubated	4.0 (44.4%)	110.0 (42.0%)	1.000	4.0 (50.0%)	80.0 (60.6%)	0.713
Congenital disease	5.0 (55.6%)	80.0 (30.5%)	0.144	2.0 (25.0%)	23.0 (17.4%)	0.633
Neurological manifestation	4.0 (44.4%)	24.0 (9.2%)	0.008	3.0 (37.5%)	35.0 (26.5%)	0.683
Arrested in Hospital	9.0 (100.0%)	259.0 (98.9%)	1.000	7.0 (87.5%)	124.0 (93.9%)	0.421
Heart rate	70 (60, 130)	46 (40, 61)	0.037	78 (54, 119)	56 (40, 105)	0.286
Respiratory rate	32 (22, 38)	35 (23, 42)	0.497	20 (20, 30)	30 (19, 36)	0.432
Oxygen saturation (%)	70 (50, 73)	54 (35, 66)	0.283	75 (60, 92)	40 (35, 66)	0.003
Duration of CPR, minutes	2 (1, 5)	20 (15, 20)	<0.001	8 (5, 11)	20 (11, 20)	<0.001

Note: Bold indicates significance (at P value <0.05).

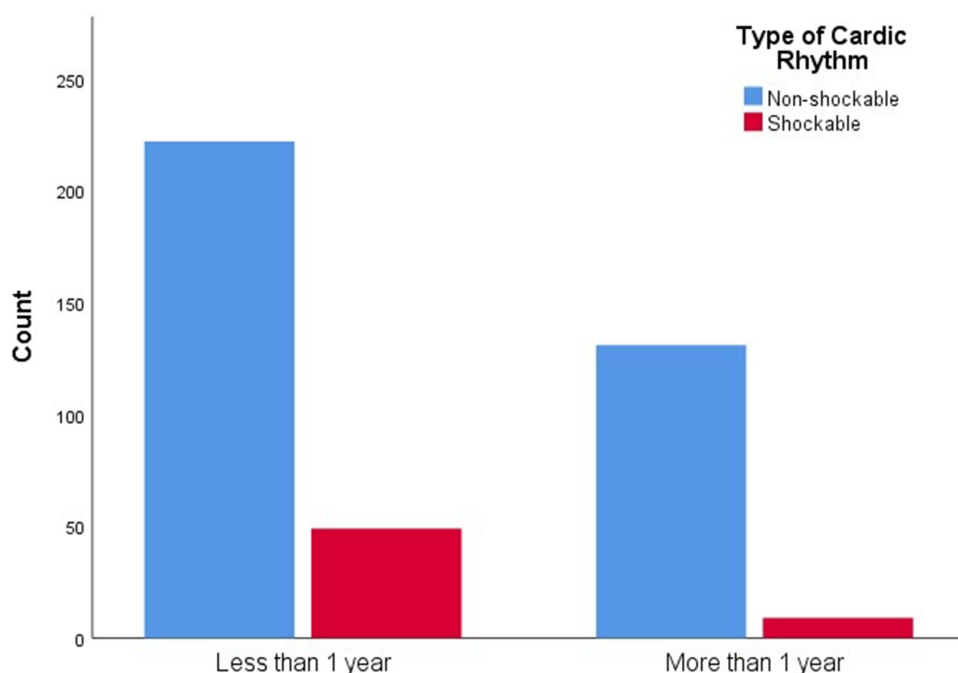


Figure 1 Distribution of Non-Shockable (Asystole + PEA) and Shockable (VF/pVT) Cardiac Rhythms by Age Group.

None of the surviving patients were preterm, whereas 91 patients (34.7%) in the deceased group were preterm ($p=0.031$). Additionally, the survived group generally took less medication (33.3% vs 71.0%, $p=0.024$). On the other hand, 44.4% of the survived group had a neurological manifestation compared to 9.2% of those who died ($p=0.024$).

The median heart rate was higher in the survived group at 70 beats per minute (60, 130) compared to 46 beats per minute (40, 61) in the deceased group ($p=0.037$). The median duration of CPR was significantly shorter for survivors at two minutes (1, 5) compared to 20 minutes (15, 20) for the deceased group ($p<0.001$).

The duration of CPR was also a significant factor associated with survival in the more than one year group. The median duration for the survived group was 8 minutes (5, 11), compared to 20 minutes (11, 20) for the deceased group ($p<0.001$). In addition, survived patients had a higher median oxygen saturation (75% vs 40%, $p=0.003$).

Regarding patients' cardiac rhythm, most of the patients were non-shockable, for both age groups, as shown in Figure 1.

Of the 266 patients who received medications, epinephrine was administered in 255 (96%), dopamine in 10 (4%), dobutamine in 3 (1%), and other adjuncts in a minority of cases ($n = 4$, 1%).

Binary Logistic Regression Analysis

We examined the association between several factors as mentioned in the methodology section and the survival of pediatric patients' post-CPR, and we found that four factors were significantly associated with survival: duration of CPR, oxygen saturation, heart rate, and neurological manifestation. (Table 3)

Out of them, two variables were found to be significantly associated with survival by multivariable logistic regression using a backward stepwise approach. Where, each 1% increase in oxygen saturation was associated with an increase in the adjusted odds ratio (AOR) of 1.08 (95% CI: 1.01–1.15, $p=0.031$). In contrast, a minute increase in the duration of CPR was associated with a decrease in the AOR of 0.38 (95% CI: 0.21–0.72, $p=0.003$). Having congenital neurological manifestations or heart rate was not associated with survival.

Excluding the 12 out-of-hospital arrests (OHCA) ($N = 399$) left the key predictors unchanged: oxygen saturation AOR 1.08 (95% CI: 1.00–1.15, $p = 0.038$) and CPR duration AOR 0.39 (95% CI: 0.21–0.74, $p = 0.004$). No other variable gained or lost significance (Table S.1).

Table 3 Binary Logistic Regression Analysis for Prediction of the Patient Status at Discharge (Alive vs Deceased)

	OR (95% CI)	P value	AOR (95% CI)	P value
Age, months	1.00 (0.98–1.02)	0.885		
Preterm	0.20 (0.03–1.55)	0.124		
Intubation	0.95 (0.36–2.52)	0.925	0.08 (0.00–1.99)	0.123
Congenital disease	1.98 (0.73–5.33)	0.178		
Neurological manifestation	3.97 (1.46–10.86)	0.007		
Location of arrest				
Hospital	0.46 (0.06–3.78)	0.470	0.00 (0.00–1.48)	0.060
Other locations	1		1	
Heart rate	1.01 (1.00–1.02)	0.036		
Respiratory rate	0.98 (0.95–1.02)	0.299	0.88 (0.77–1.01)	0.077
Oxygen saturation (%)	1.04 (1.02–1.07)	0.003	1.08 (1.01–1.15)	0.031
Duration of CPR, minutes	0.69 (0.60–0.79)	<0.001	0.38 (0.21–0.72)	0.003

Notes: Bold indicates significance (at P value <0.05). Outcome variable: survived or not.

Abbreviations: AOR, Adjusted Odds Ratio; CI, confidence interval; OR, Odds Ratio.

Discussion

In this study, we aimed to measure the survival rates of pediatric patients who underwent CPR in KAUH (ED and in-hospital), identify the factors affecting the outcomes, and determine the risk factors associated with poor outcomes.

The overall survival rates were low in all age groups, mirroring other studies. Especially in the less than one year age group and preterm, where they were 0%, unlike the greater than one year age group in both genders. These results can be explained by the fact that most of the patients aged less than one year suffered from prematurity, which could be assigned to their physiological weaknesses, including being more susceptible to side effects and immature organ systems. Higher survival rates have been observed in Spain (41%) and the United States (43.4%).^{16,17} On the other hand, markedly lower rates were reported in Taiwan (20.9%) and Turkey (14.9%).^{3,18}

Interestingly, the longer duration of CPR negatively affected the outcomes and survival rate; a minute increase in the duration of CPR was associated with a decrease in the odds of survival, paralleling another study conducted in the USA.¹⁹

In the “more than one year” group oxygen saturation demonstrated a substantial correlation with survival outcomes ($p = 0.003$). The median oxygen saturation of survivors in this group was 75% (60–92%), which was significantly greater than the 40% (30–66%) observed in the fatal group. The finding implies that increased oxygen saturation levels are essential for maintaining life beyond the acute phase and may signal improved respiratory and circulatory function during critical periods. In contrast, the “less than one year” survival group, although median oxygen saturation was markedly higher in survivors (70% vs 54%), the difference failed to achieve statistical significance ($p = 0.283$). This study also found that the more medications used during CPR, the higher the rate of death, particularly in patients aged less than one year, where the death rate was about 71%. This highlights the need for caution when administering medications during CPR, particularly in young patients. However, this relationship was not significant in patients aged more than one year.

Epinephrine is commonly used during pediatric in-hospital cardiac arrest because it enhances blood flow to the heart and brain by raising vascular resistance. While there is no strong pediatric trial proving it improves survival, giving epinephrine late is linked to worse outcomes in children.⁷ However, the number of epinephrine doses given during resuscitation was strongly linked to higher death rates. Using more than 10 doses and performing CPR for over 30 minutes both significantly increased mortality. Each additional dose of epinephrine also raised the risk of death.²⁰

Among those aged greater than one year, eight patients survived, and three of them had a neurological problem; this should warrant the need for better post-arrest care among survivors.^{7,19,21} In contrast, some studies showed that up to 90% had favourable neurological outcomes among survivors. This variation needs more studies to better characterize neurocognitive and neurobehavioral outcomes among survivors.⁷ Survivors in the “less than one year” group had a median CPR duration of 2 minutes (1–5 minutes), which was substantially shorter than the 20 minutes (15–20 minutes)

observed in the deceased group. In the same vein, the median CPR duration of survivors in the “more than one year” group was 8 minutes (5–11 minutes), which was significantly shorter than the 20 minutes (11–20 minutes) observed in non-survivors.

The survival rates of both groups were not significantly associated with specific factors that were examined in this study. Out of these, intubation was the first to not substantially affect survival outcomes, with p-values of 1.000 and 0.713 for the “less than one year” and “more than one year” survival groups, respectively. This discovery suggests that intubation, although essential for immediate life support, does not serve as an indicator of long-term survival. Secondly, congenital disease was associated with p-values of 0.144 for the “less than one year” group and 0.633 for the “more than one year” group. Finally, gender did not emerge as a significant factor affecting survival in either the “less than one year” or “more than one year” survival categories, as indicated by p-values of 0.180 and 0.476, respectively.

Children who arrive while CPR is still underway are, by definition, cases of OHCA and may behave differently from in-hospital arrests. To check whether these 12 cases biased our findings, we re-ran the model without them. Oxygen saturation and CPR duration stayed significant, and their adjusted odds ratios barely changed, showing that our main conclusions do not hinge on this small OHCA group. Still, because OHCA cases made up only ~3% of the cohort, we could not probe location-specific strategies in detail. Larger, multi-centre studies that oversample paediatric OHCA are needed to fill that gap.

In Jordan, the Civil Defense provides prehospital emergency services through a national ambulance system equipped with basic life support. However, many families choose to transport pediatric patients directly to the hospital, often due to perceived faster response times or being unfamiliar with requesting emergency services. In addition, KAUH is a 750-bed tertiary centre that serves ~1 million inhabitants of northern Jordan; its Emergency Department receives ~70,000 visits each year, about one-quarter of which are pediatric.^{22,23} This catchment context should be taken into account when interpreting our out-of-hospital arrest data.

Study Limitation

The lack of data on the quality of CPR performed and post-arrest care shows a need for further studies and research, focusing on this field to improve survival rates and neurological complications. Also, although near-arrest vital-sign readings can be affected by low perfusion and motion, they are the standard bedside data available in practice; future prospective work with waveform-validated or arterial measurements would further refine these observations. In addition, several optional Paediatric Utstein items—including witness status, collapse-to-CPR and collapse-to-defibrillation intervals, and neurological outcome scores—were missing from the retrospective charts, which limits direct comparison with fully Utstein-compliant datasets.

Conclusion

Our study showed that pediatric CPR survival rates at our center were generally low, with no survivors among preterm infants and children under one year of age. Most importantly, shorter CPR duration and higher oxygen saturation were independently associated with increased survival.

As the first study to evaluate pediatric CPR outcomes in Jordan, our findings provide a crucial foundation for improving the current healthcare system. We recommend more focused training for pediatric care teams with maintaining optimal oxygenation and minimizing prolonged CPR duration. It is also encouraged to expand CPR training into the community to help save lives by improving early intervention before reaching the hospital.

Data Sharing Statement

Upon reasonable request, the author can provide the datasets generated and analyzed during the current study.

Ethical Considerations

All human participant procedures conducted in this study were ethically approved by the Institutional Review Board (IRB) at Jordan University of Science and Technology (JUST), Irbid, Jordan (IRB number: 30/152/2022) after review and approval. The study was conducted in accordance with the 1975 helsinki Declaration, which was revised in 2008,

and other amendments or ethical standards that were similar. The patients' data was not disclosed, and the analysis was done on the de-identified database.

Informed Consent

We obtained an informed consent from participant's parent or guardian to participate in this study.

Author Contributions

All authors have read and approved the final version of the manuscript. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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