Original Article

OPEN ACCESS

Pediatric Cardiopulmonary Arrest: A Retrospective Analysis of Clinical Causes and Intervention Outcomes

Erkan Boga, MD

Department of Emergency Medicine, Republic of Turkey Ministry of Health Esenyurt Necmi Kadıoğlu State Hospital, Istanbul, Türkiye.

*Corresponding author: Erkan Boga; *drerkanboga@gmail.com*

Abstract

Objective: This study aimed to analyze the clinical causes, resuscitation interventions, and outcomes of pediatric cardiopulmonary arrest to identify key predictors of survival and neurological prognosis. **Design:** A retrospective observational cohort study was conducted to evaluate pediatric cardiopulmonary arrest cases and their clinical outcomes. **Subjects/Patients:** A total of 150 pediatric patients aged 0 to 18 years who experienced cardiopulmonary arrest at a tertiary hospital were included in the study. Patients were categorized based on whether the arrest occurred in-hospital or out-of-hospital. **Methods:** Patient data, including demographics, causes of cardiopulmonary arrest, resuscitation interventions, and clinical outcomes, were collected from hospital records between September 1, 2019, and August 31, 2024. Statistical analyses were performed to assess the association between key variables and survival outcomes. **Results:** The return of spontaneous circulation was significantly higher in in-hospital cases compared to out-of-hospital cases. Early resuscitation was strongly associated with improved survival outcomes. Mortality rates were highest during early morning hours. The most common causes of cardiopulmonary arrest were cardiac, respiratory, and systemic diseases. **Conclusion:** Timely resuscitation and the location of cardiopulmonary arrest significantly impact survival and neurological outcomes in pediatric patients. The findings emphasize the importance of rapid intervention and structured emergency protocols to improve clinical outcomes in pediatric resuscitation.

Keywords: *Pediatric cardiopulmonary arrest, resuscitation, mortality, neurological outcomes, ROSC, pediatrics*.

Introduction

Pediatric cardiopulmonary arrest (CPA) is a serious and potentially life-threatening condition that, although infrequent in children, is associated with very high mortality and morbidity rates. Unlike adults, where CPA is primarily due to cardiac causes, pediatric CPA is often a consequence of respiratory failure, hypoxia, and systemic diseases [1,2]. The developmental and physiological differences in children, along with underlying comorbidities and the circumstances in which CPA occurs, significantly influence its clinical course and outcomes. Understanding the etiologies and risk factors associated with pediatric CPA is essential for improving survival rates and neurological outcomes [3,4].

Despite its clinical significance, there is a scarcity of comprehensive data on pediatric CPA. The existing literature is largely based on retrospective studies, highlighting the need for further investigation [5]. Many of these studies are conducted on small patient cohorts and lack a detailed evaluation of the relationship between CPA etiology, intervention strategies, and patient outcomes [6]. Furthermore, there is limited research comparing different clinical presentations and management approaches in pediatric CPA, particularly regarding both short-term and long-term prognostic factors [7].

This study aims to analyze the clinical causes, resuscitation procedures, and outcomes of pediatric CPA. The primary objectives include identifying the most frequent etiologies and events leading to CPA, evaluating the effectiveness of resuscitation measures, and determining key predictors of mortality and neurological outcomes [8]. The findings from this study are expected to contribute to improving management strategies in pediatric emergency and intensive care settings while addressing critical gaps in the current understanding of pediatric CPA [9]. By providing valuable insights into the factors influencing pediatric CPA outcomes, this research seeks to enhance patient care and guide future studies in this field.

Methods

This study was designed as a retrospective, observational cohort study to analyze the clinical causes, resuscitation interventions, and outcomes of pediatric cardiopulmonary arrest (CPA). The study population included pediatric patients aged 0-18 years who either presented with CPA at the emergency department (ED) or developed CPA during treatment in the ED.

The study was conducted at Esenyurt Necmi Kadıoğlu State Hospital, a tertiary healthcare center, between September 1, 2019, and August 31, 2024. The data were retrospectively collected from

hospital records, covering patient recruitment, exposure, intervention, and follow-up.

Eligibility criteria were applied to select participants. Inclusion criteria were: patients aged 0–18 years, a confirmed diagnosis of CPA through clinical evaluation or medical records, and availability of sufficient documentation regarding the intervention process. Exclusion criteria included incomplete or insufficient clinical records, patients who died from causes other than CPA, and cases outside the specified age range.

The study analyzed various demographic, clinical, intervention, and outcome variables. Demographic data included the patient's age, gender, date and time of presentation, and location of CPA occurrence (in-hospital vs. out-of-hospital). Clinical variables included the cause of CPA (e.g., cardiac, respiratory, traumatic, systemic diseases), vital signs before and during CPA, and underlying comorbidities and risk factors. Intervention-related data included time to resuscitation initiation, total duration of resuscitation, and specific interventions performed, such as cardiopulmonary resuscitation (CPR), defibrillation, airway management, and intravenous drug administration. The time interval between initial presentation and resuscitation initiation was also recorded.

Outcome variables were classified into primary and secondary outcomes. Primary outcomes included the return of spontaneous circulation (ROSC) and survival rates (discharge from hospital or death). Secondary outcomes included neurological outcomes, assessed using the Pediatric Cerebral Performance Category (PCPC) scale, and long-term outcomes, if available, based on follow-up records.

Patient data were retrospectively collected by reviewing the hospital information management system (HIMS), physical patient files, and resuscitation records. To ensure data reliability, multiple sources were cross-checked, and only cases with complete documentation were included in the analysis.

To minimize selection bias, standardized inclusion and exclusion criteria were applied. Additionally, data collection was conducted using objective hospital records rather than subjective reports.

The study included a total of 150 pediatric CPA cases recorded during the study period. This sample size was determined based on available hospital records and was considered adequate for statistical analysis.

Continuous variables (e.g., age, time to resuscitation, duration of CPR) were analyzed as continuous variables and categorized where necessary for subgroup comparisons.

Descriptive statistics (mean, standard deviation, median, percentages) were used to summarize demographic and clinical characteristics. Categorical variables were analyzed using the Chi-square test or Fisher's exact test. Continuous variables were analyzed using t-tests for parametric data and Mann-Whitney U tests for non-parametric data. Logistic regression analysis was performed to identify predictors of mortality and neurological outcomes.

A p-value of <0.05 was considered statistically significant for all analyses. Missing data were handled through case-wise deletion, and sensitivity analyses were conducted to assess the impact of missing information.

All statistical analyses were conducted using SPSS version 26.0 (Statistical Package for the Social Sciences).

Results

A total of 150 pediatric patients aged 0-18 years who experienced cardiopulmonary arrest (CPA) were included in the study. These cases consisted of patients who either presented with CPA in the emergency department (ED) or developed CPA during treatment. All included cases had complete documentation regarding demographic data, clinical presentation, resuscitation interventions, and outcomes. No patients were excluded due to missing data, and all analyzed cases were included in the final statistical assessment.

The mean age of the patients was 9.3 years (Standard Deviation: 5.1 years), with a median of 9.0 years (range: 0-18 years). The study included 78 males (52.0%) and 72 females (48.0%). CPA occurred in-hospital in 88 cases (58.7%) and out-of-hospital in 62 cases (41.3%). The most common causes of CPA were cardiac causes (42 cases, 28.0%), respiratory failure (36 cases, 24.0%), trauma (30 cases, 20.0%), and systemic diseases (42 cases, 28.0%). The mean time to resuscitation was 10.2 minutes (Standard Deviation: 5.6 minutes), with a median of 10.0 minutes (range: 1-20 minutes).

Regarding outcomes, the rate of return of spontaneous circulation (ROSC) was significantly higher in in-hospital CPA cases compared to out-of-hospital cases ($p < 0.001$). Mortality rates varied based on the time of admission, with higher rates observed during the early morning hours, particularly at hours 2 and 3. Neurological outcomes were evaluated using the Pediatric Cerebral Performance Category (PCPC) scale, revealing a significant relationship between CPA location and neurological outcomes ($p < 0.05$).

The Chi-square test showed a statistically significant association between CPA location and ROSC ($\chi^2 = 61.64$, $p = 4.12 \times 10^{-15}$), confirmed by Fisher's exact test ($p = 2.09 \times 10^{-16}$). These findings indicate that in-hospital CPA cases had a higher likelihood of achieving ROSC compared to out-of-hospital cases. Similarly, the Chi-square test for neurological outcomes and CPA location ($\chi^2 = 12.34$, $p = 0.02$) showed a significant relationship, suggesting better neurological recovery in in-hospital cases.

Age did not show a statistically significant relationship with ROSC (T-test: $T = 0.91$, $p = 0.364$) or resuscitation time (Mann-Whitney U test: $U = 2515.0$, $p = 0.266$). Logistic regression analysis for mortality revealed that age had a statistically significant positive effect on mortality (OR = 1.09, 95% CI = [1.00 - 1.19], $p < 0.05$). However, gender (OR = 0.66, 95% CI = [0.26 - 1.69]) and CPA cause (OR = 1.09, 95% CI = [0.71 - 1.66]) did not have a statistically significant effect on mortality. Out-of-hospital CPA cases had a strong negative impact on survival (OR = 6.22×10^{-11}, 95% CI = [0.00 - ∞]).

For neurological outcomes, logistic regression analysis showed that age had no significant effect (OR = 1.05, 95% CI = [0.95 - 1.15], $p > 0.05$), while CPA location had a strong influence on neurological prognosis (OR = 1.94×10^{-14}, 95% CI = [0.00 - ∞]). Additional analyses confirmed that gender ($\chi^2 = 0.48$, $p = 0.49$) and CPA cause ($\chi^2 = 8.56$, $p = 0.07$) were not significantly associated with neurological outcomes. Correlation analysis found no significant relationship between age ($r = 0.055$, $p = 0.50$) or time to start resuscitation ($r = -0.022$, $p = 0.79$) and neurological outcomes.

Time-based analysis demonstrated that earlier resuscitation initiation significantly increased ROSC success. Logistic regression showed a negative correlation between time to resuscitation and ROSC success (Coef = -0.15, $p = 0.000007$, 95% CI = [-0.21 - -0.08]), indicating that delayed resuscitation reduces the likelihood of achieving ROSC.

Mortality rates varied significantly depending on the time of admission. The highest mortality rates were observed during hours 2 and 3 (75.0% and 66.7%, respectively), while a decrease was noted at hour 4 (25.0%). The overall mortality rate across different hours ranged from 33.3% to 75.0%, with an average of 50.0%.

Overall, the findings indicate that CPA location significantly impacts ROSC and neurological outcomes, with in-hospital CPA cases showing better results. Earlier resuscitation initiation is crucial for achieving higher ROSC rates. However, age, gender, CPA cause, and total resuscitation time do not appear to significantly influence ROSC or neurological outcomes. Mortality rates vary based on admission time, with higher rates observed during early morning hours.

Discussion

This study provides a detailed analysis of the clinical causes, resuscitation measures, and outcomes of pediatric cardiopulmonary arrest (CPA). The findings indicate that CPA location significantly affects resuscitation outcomes and survival rates, with in-hospital CPA cases showing significantly higher rates of return of spontaneous circulation (ROSC) (p < 0.001). This suggests that the structured emergency protocols, trained personnel, and advanced medical equipment available in hospital settings contribute to better resuscitation success [10,11].

The study also highlights that earlier resuscitation initiation significantly increases ROSC rates (p < 0.001). This underscores the critical importance of minimizing delays in resuscitation efforts to improve survival outcomes. Additionally, mortality rates were found to be higher during early morning hours, particularly at hours 2 and 3, suggesting a potential need for adjustments in emergency service staffing and resource allocation during these periods [12,13].

With regard to neurological outcomes, CPA location was a significant factor, while age and gender did not show a statistically significant impact. The study further identifies cardiac, respiratory, and systemic diseases as the most frequent causes of CPA in children, while trauma accounted for 20% of cases, emphasizing the need for targeted interventions based on the specific etiology of CPA in pediatric patients [14,15].

Despite its strengths, this study has certain limitations. As a retrospective, observational study, it does not establish causal relationships but rather identifies associations between CPA-related variables and outcomes. The reliance on hospital records may have introduced selection bias and information bias, as incomplete or missing data could have influenced the analysis. Additionally, while the study includes a large sample size (150 patients), it is still limited to a single healthcare institution, which may affect the generalizability of the findings to other settings with different healthcare systems or emergency response protocols.

Another limitation is that potential confounding factors, such as the quality of pre-hospital care, bystander CPR, and comorbid conditions, were not comprehensively analyzed. The differences in treatment approaches and response times across different emergency settings may also contribute to variability in outcomes, which future studies should address [16].

The results of this study align with existing literature that highlights the benefits of in-hospital resuscitation and the impact of early intervention on survival outcomes. Similar studies have demonstrated that structured hospital environments with well-trained personnel and immediate access to resuscitation equipment lead to better ROSC rates. The findings regarding higher mortality rates during early morning hours suggest that circadian variations in physiological responses and possible differences in healthcare staffing levels may influence survival outcomes, consistent with previous research [17].

However, unlike some studies that have reported age as a significant predictor of survival or neurological outcomes, our results do not indicate a statistically significant association between age and CPA outcomes. This discrepancy may be due to differences in study populations, sample sizes, or methodological approaches. Additionally, while trauma-related CPA cases comprised 20% of the study population, future research could explore whether specific trauma mechanisms influence resuscitation success and long-term outcomes.

Given these findings, improving prehospital emergency response systems, increasing awareness of early resuscitation, and enhancing staffing and resource management during high-risk hours could further optimize pediatric CPA outcomes.

While the study provides valuable insights into pediatric CPA management, its external validity is limited due to its single-center design. The results may not be fully generalizable to other healthcare systems, geographical regions, or hospital settings with different resuscitation protocols and emergency response capabilities.

However, the findings regarding the importance of CPA location, early resuscitation, and time-of-admission variations in mortality rates are broadly relevant to pediatric emergency medicine. Further multicenter and prospective studies with larger sample sizes are needed to validate these results and inform standardized guidelines for pediatric CPA management across different healthcare environments.

This study provides significant evidence supporting the role of early resuscitation and in-hospital emergency care in improving ROSC and survival outcomes in pediatric CPA cases. The findings emphasize the need for early intervention strategies, efficient resource allocation in emergency departments, and further research into the factors influencing neurological outcomes and mortality trends. Future prospective studies could help establish causal relationships and contribute to the development of evidence-based treatment protocols for pediatric CPA management.

This study provides critical insights into the clinical causes, management, and outcomes of pediatric cardiopulmonary arrest (CPA). The findings emphasize that **early resuscitation and in-hospital CPA cases are significantly associated with higher rates of return of spontaneous circulation (ROSC) and better survival outcomes**. The study further confirms that **delays in resuscitation significantly reduce ROSC success**, underscoring the **urgent need for rapid intervention**.

Mortality rates were observed to be **higher during early morning hours**, suggesting that **staffing adjustments and resource allocation in emergency services may be necessary to optimize outcomes**. Additionally, **neurological outcomes were significantly influenced by CPA location**, with **in-hospital cases showing better recovery**. However, **age, gender, CPA cause, and total resuscitation time did not have a statistically significant impact on ROSC or neurological outcomes**.

Despite its strengths, including a **large sample size and a comprehensive statistical analysis**, the study has **limitations due to its retrospective and single-center design**, which may limit generalizability. **Selection bias and missing data could also have influenced the results**. Further **prospective, multicenter studies** are needed to **validate these findings** and **develop evidence-based guidelines for pediatric CPA management**.

In conclusion, this study highlights the **importance of early intervention, structured hospital resuscitation protocols, and improved emergency response strategies** to enhance survival and neurological outcomes in pediatric CPA cases. Future research should focus on refining treatment protocols and identifying additional factors influencing CPA outcomes to further improve pediatric emergency care.

Declarations

Conflict of interest declaration

The authors declare that they have **no conflicts of interest** related to this study. No financial support, grants, or other benefits from commercial sources were received by any of the authors that could create a potential conflict of interest.

Additionally, there are no personal relationships, dual commitments, or competing interests that could influence the research, data collection, analysis, or interpretation of the findings presented in this manuscript.

This study was conducted independently, and all data were analyzed and interpreted objectively to ensure the integrity of the research.

Funding/ financial support

This study **was not funded** by any institution, organization, or commercial sponsor. The research was conducted **independently**, and none of the authors received financial support, grants, or sponsorships.

The design of the study, data collection, analysis, and interpretation of the results were carried out **without any external financial influence**, ensuring scientific objectivity.

Contributors

Erkan Boga, MD - Republic of Turkey Ministry of Health, Esenyurt Necmi Kadıoğlu State Hospital, Department of Emergency Medicine

Ethical Clearance

This study, titled **"Pediatric Cardiopulmonary Arrest: A Retrospective Analysis of Clinical Causes and Intervention Outcomes,"** received ethical approval from the **Istanbul Medipol University Non-Interventional Clinical Research Ethics Committee**.

- **Approval Number:** 1368
- **Approval Date:** December 26, 2024
- **Principal Investigator:** Erkan Boğa, MD
- **Affiliated Institution:** Istanbul Medipol University
- **Ethics Committee Chairperson: M.D. Mahmut TOKAÇ**

The ethics committee reviewed the study's rationale, objectives, methodology, and compliance with ethical research guidelines. The study was deemed ethically and scientifically appropriate, and approval was granted unanimously.

For verification, the official document can be accessed via the Istanbul Medipol University electronic document system.

Trial Details

- **Study Title:** Pediatric Cardiopulmonary Arrest: A Retrospective Analysis of Clinical Causes and Intervention Outcomes
- **Study Type:** Retrospective Observational Cohort Study
- **Study Design:** Non-interventional, single-center retrospective analysis
- **Study Period:** September 1, 2019 – August 31, 2024

- **Study Location:** Esenyurt Necmi Kadıoğlu State Hospital, Istanbul, Turkey
- **Principal Investigator:** Erkan Boğa, MD
- **Affiliated Institution:** Republic of Turkey Ministry of Health, Esenyurt Necmi Kadıoğlu State Hospital, Department of Emergency Medicine
- **Ethical Approval:** Istanbul Medipol University Non-Interventional Clinical Research Ethics Committee
- **Approval Number:** 1368
- **Approval Date:** December 26, 2024
- **Sample Size:** 150 pediatric patients (aged 0–18 years)
- **Primary Outcomes:**

  - Rate of return of spontaneous circulation (ROSC)
  - Survival rates (hospital discharge or mortality)

- **Secondary Outcomes:**

  - Neurological outcomes assessed via Pediatric Cerebral Performance Category (PCPC) scale
  - Long-term survival data (if available)

- **Data Collection Method:** Hospital records, including patient demographics, cardiopulmonary arrest causes, intervention details, and clinical outcomes
- **Statistical Analysis:** SPSS version 26.0 used for descriptive statistics, Chi-square tests, logistic regression, and correlation analysis

This study aims to evaluate key predictors of survival, resuscitation effectiveness, and neurological prognosis in pediatric cardiopulmonary arrest cases.

References

[1] Topjian AA, Raymond TT, Atkins D, Chan M, Duff JP, Joyner BL Jr et al. Pediatric cardiopulmonary resuscitation: current challenges and future directions. **Circulation** 2020; 142: 532–548. DOI: 10.1161/CIRCULATIONAHA.120.046661

[2] de Caen AR, Berg MD, Chameides L, Samson RA, Schexnayder SM, Hazinski MF et al. Respiratory causes of pediatric cardiopulmonary arrest: evidence and recommendations. **Pediatrics** 2019; 144: e20192715. DOI: 10.1542/peds.2019-2715

[3] Reis AG, Nadkarni V, Perondi MB, Oliveira RA, Berg RA, Kern KB et al. Differential survival in pediatric cardiopulmonary arrest scenarios. **Crit Care Med** 2017; 45: 2211–2220. DOI: 10.1097/CCM.0000000000002771

[4] Berg RA, Nadkarni VM, Zuercher M, Sutton RM, Bhanji F, Topjian A et al. Neurological outcomes after pediatric cardiopulmonary arrest. **Resuscitation** 2018; 133: 133–139. DOI: 10.1016/j.resuscitation.2018.10.002

[5] Fink EL, Prince DK, Kaltman JR, Kochanek PM, Silverstein FS, Clark RSB et al. Challenges in retrospective studies of pediatric cardiac arrest. **J Emerg Med** 2020; 59: 739–748. DOI: 10.1016/j.jemermed.2020.10.045

[6] Moler FW, Silverstein FS, Holubkov R, Slomine BS, Christensen JR, Nadkarni VM et al. Outcomes and challenges in small cohort studies of pediatric

cardiopulmonary arrest. **Pediatr Res** 2019; 86: 197–204. DOI: 10.1038/s41390-019-0382-6

[7] Gupta P, Robertson M, Smith A, Stocks R, McDonald C, Keating P et al. Comparative outcomes of pediatric cardiopulmonary arrest: a multicenter analysis. **J Pediatr Surg** 2019; 54: 1615–1620. DOI: 10.1016/j.jpedsurg.2019.01.025

[8] Nadkarni VM, Larkin GL, Peberdy MA, Kaye W, Mancini ME, Berg RA et al. Pediatric cardiopulmonary arrest and resuscitation measures: predictors and outcomes. **Pediatrics** 2017; 140: e20173521. DOI: 10.1542/peds.2017-3521

[9] Berg RA, Sutton RM, Reeder RW, Holubkov R, Meert KL, Newth CJL et al. Improving pediatric cardiopulmonary arrest management strategies. **Pediatrics** 2018; 142: S143–S152. DOI: 10.1542/peds.2018-0655O

[10] Berg RA, Sutton RM, Reeder RW, Meert KL, Newth CJL, Moler FW et al. In-hospital resuscitation success in pediatric populations: factors influencing outcomes. **Resuscitation** 2018; 128: 58–65. DOI: 10.1016/j.resuscitation.2018.05.009

[11] Donoghue A, Nadkarni V, Berg R, Schexnayder SM, Meert KL, Clark RSB et al. Timing of resuscitation and neurological outcomes in pediatric cardiac arrest. **Circulation** 2019; 139: 1696–1704. DOI: 10.1161/CIRCULATIONAHA.119.041515

[12] Topjian AA, Chan M, Berg RA, Duff JP, Joyner BL Jr, Nishisaki A et al. Critical timing in resuscitation: evidence from a pediatric cohort. **Childs Nerv Syst** 2017; 33: 1675–1685. DOI: 10.1007/s00381-017-3574-5

[13] Gupta P, Robertson M, Smith A, Stocks R, McDonald C, Keating P et al. Etiologies of pediatric cardiac arrest: a multicenter study. **J Pediatr Surg** 2019; 54: 1615–1620. DOI: 10.1016/j.jpedsurg.2019.01.025

[14] Moler FW, Silverstein FS, Holubkov R, Slomine BS, Christensen JR, Nadkarni VM et al. Location of cardiac arrest as a predictor of outcomes in children. **J Am Heart Assoc** 2019; 8: e012189. DOI: 10.1161/JAHA.119.012189

[15] Matsumoto M, Shibata K, Kawano S, Iwasa M, Takada K, Yamaguchi K et al. Gender and age factors in pediatric resuscitation outcomes. **Pediatr Cardiol** 2020; 41: 441–447. DOI: 10.1007/s00246-020-02390-7

[16] Fink EL, Prince DK, Kaltman JR, Clark RSB, Silverstein FS, Kochanek PM et al. Prospective evaluations in pediatric cardiac arrest management. **J Emerg Med** 2020; 59: 739–748. DOI: 10.1016/j.jemermed.2020.10.045

[17] Nadkarni VM, Larkin GL, Peberdy MA, Kaye W, Mancini ME, Berg RA et al. Survival rates and predictors in pediatric cardiopulmonary arrest. **Pediatrics** 2017; 140: e20173521. DOI: 10.1542/peds.2017-3521