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Original Article

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The Effect of the Time of In-hospital Cardiopulmonary Resuscitation on the Immediate Outcome in Pediatric Patients

Behdad Gharib and Sara Memarian *

Tehran University of Medical Sciences, Children's Medical Center, Tehran, Iran

Abstract

Background: We aimed to identify the factors affecting the in-hospital Cardiopulmonary Resuscitation (CPR) to investigate the effect of the time of in-hospital CPR on its immediate outcome in pediatric patients.

Methods: This retrospective study investigated CPR events performed at a teaching hospital in Tehran, Iran, from March 2018 to March 2019. After obtaining the necessary academic and ethical approvals, the pertinent data were transcribed from patient records and analyzed. No identifying data about patients or their families were extracted.

Results: Chi-square test showed a significant difference in the occurrence of CPR on two-hour time blocks (p=0.041), with dips at 0-2 a.m. and 12-2 p.m. and heights at 2-4 p.m. and 6-8 p.m. (representing 5, 6, 17 and 17 CPR events, respectively). The occurrence of CPR during the night shift was significantly less than in the morning and evening shifts (p=0.000 and 0.005 respectively). Of 161 subjects with a known immediate outcome of CPR, 86 (53.4%) survived, and 75 (46.6%) died. The outcome was significantly less favorable in the evening shift compared to the morning shift (p=0.028), but no significant differences in the outcome were found between morning and night shifts (p=0.163), evening and night shifts (p=0.256), day and night (p=0.637) or workdays and weekends (p=0.925).

Conclusion: We found a significantly higher occurrence of CPR at 2-4 p.m. and 6-8 p.m., at the beginning and end of the evening shift and a higher rate of post-CPR death in this shift.

Keywords: Cardiopulmonary resuscitation (CPR), Child, Hospitals

*** Corresponding author**

Sara Memarian, MD
Tehran University of Medical Sciences, Children's Medical Center, Tehran, Iran
Tel: +98 21 61479
Email: saramemarian64@gmail.com

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Introduction

The mortality rate of pediatric In Hospital Cardiac Arrest (IHCA) is high and the survival rates were reported as 41.1% compared to 11.4% for Out-Hospital Cardiac Arrest (OHCA). Also, the survival rates of IHCA differs among departments and cardiac arrest in the emergency department has higher mortality than Inpatient Cardiac Arrest (IPCA) (1). Mckenzie *et al* found that a high proportion of pediatric OHCA had ROSC (Return of spontaneous circulation), but the rate of survival to discharge was low (2). Bimerew *et al* conducted a meta-analysis which showed that 54 percent of pediatric patients with the event of in hospital cardiac arrest and CPR, did not survive to discharge (3).

Several factors have been implicated in determining the outcome of CPR, prominent among them the clinical setting in which the procedure is performed, including the emergency department, general departments and Intensive Care Unit (ICU). De Mos *et al* found an overall high incidence of mortality among pediatric ICU patients after cardiac arrest (4), while Ortmann *et al* reported significantly more favorable survival in hospitalized surgical-cardiac pediatric patients than in medical-cardiac pediatric patients experiencing cardiac arrest (5). Lowry *et al* reported that 7 out of each 1000 hospitalized pediatric patients with the cardiovascular disease require CPR, ten-fold more than those without cardiovascular disease (6).

The age of pediatric patients has been studied in relation to CPR outcome. Meaney *et al* studied 464 Pediatric Intensive Care Unit (PICU) patients and their outcomes following cardiac arrest. They suggested that age significantly affected the survival after cardiac arrest, with newborns and infants having better survival rates (7).

Broadly, CPR and its outcome have been studied in relation to day versus night, work shifts, and workdays versus weekends. Marcu *et al* made a retrospective study of 202 adult patients who had received in-hospital CPR and found a lower incidence of cardiac arrest between midnight and 6 a.m. Moreover, CPRs performed during this time had the lowest likelihood of success (8). Shinohara *et al* and Lin P *et al* show that patients who were admitted during the day time after OHCA, have had higher 1-month survival rate, than those who were admitted at night (9,10). Fukuda *et al* reported that the one-month survival of pediatric OHCA was equal between weekdays and weekends and these patients had better survival when received CPR at day/evening compared to night (11). Peberdy *et al* investigated CPR outcomes during nights and weekends and found lower survival rates in these times. These results suggest that CPRs performed on day shifts and during workdays yield overall better results than the ones performed, on night shifts, and at weekends (12). Furthermore, Cavallazzi *et al* reported a lower survival rate in patients admitted to ICU at weekends versus weekdays but not in those admitted during nighttime versus daytime (13). Yu *et al* stated that in the children with Congenital Heart Disease (CHD), there was no difference in the outcome of patients who had CPR in the nighttime comparing to the daytime, but survival to hospital discharge and neurologic outcome was more favorable for the patients who had CPR during the weekdays compared to weekends (14).

Similarly, some studies have investigated the effect of the time of admission on the outcome among pediatric ICU patients. Arias *et al* retrospectively studied admissions of 15 pediatric ICUs and found an increased risk of death in evening admissions to PICU, but there was no difference between death rates of weekdays and weekends admissions (15). Thus, findings on the subject are not conclusive.

The effect of the time of CPR on the outcome in hospitalized pediatric patients was studied in 2017 by Bhanji *et al* They investigated 12404 children undergoing CPR in 354 hospitals and found a lower survival to discharge rate for CPR procedures performed at night compared to those performed during the daytime or in the evenings. However, no difference was found between CPRs on weekdays and weekends (16).

The effects of the circadian variation, the level of staffing during off-hours, and increase in error rates in physicians and nurses during night hours are among the putative factors considered (12,16-19).

The present study aimed to investigate the immediate outcome of CPR in pediatric patients admitted to a university pediatric hospital in Tehran, Iran. The effect of the sex and age of the patients, the setting of the in-hospital CPR, *i.e.*, emergency department or ward, ICUs, and the time of CPR on the outcome were studied.

Materials and Methods

This is a retrospective cross-sectional study of CPR events performed at the emergency department, cardiopulmonary and ICU wards of a teaching hospital in Tehran, Iran, from March 2018 to March 2019. After obtaining the necessary academic and ethical approvals, the pertinent data were transcribed from patient records and stored in a database.

The setting where CPR performed such as locations; the emergency department with CPR performed on the day of admission (EM same day), the emergency department with CPR performed on a later date (EM later), PICU, Neonatal Intensive Care Unit (NICU), Open-Heart surgery Neonatal Intensive Care Unit (OH NICU), cardiopulmonary ward, Cardiopulmonary ward's Intensive Care Unit (CICU), patient characteristics (sex and age), and the immediate outcome of CPR (survival or death) were extracted. As the selected wards have had better records than others, they were chosen for the current study.

Furthermore, timeframe data (information on the date and time of the patients' admission to the hospital and the CPR event) were recorded and their relationship with work shifts of the hospital was established. The morning shift was from 7 a.m. to 1:30 p.m., the evening shift from 1:30 p.m. to 7 p.m., and the night shift from 7 p.m. to 7 a.m. Consistent with the study by Peberdy *et al*, the period from 7:00 a.m. to 11:00 p.m. was designated as "day" and from 11:00 p.m. to 7:00 a.m. as night (12).

The outcome measure was survival or death upon the performance of CPR. Statistical analysis was performed using SPSS 26 (IBM Corp., Armonk, New York, USA).

Descriptive statistics for continuous variables, such as age, were reported as mean and standard deviation, and for categorical variables, such as sex, they were frequency and percentage. Chi-square goodness of fit test, chi-square test of independence, Pearson's correlation coefficient, and logistic regression models were used for the analysis of the data as applicable. The statistical significance level was set at $p<0.05$.

Results

A total of 158 subjects who underwent CPR and their data were available during the period of investigation, were included in the study. The mean age was 29.9 months, with a standard deviation of 44.12 and ranging from 0 days to 204 months. 82 (47.7%) were female and 90 (52.3%) males. The gender difference was not significantly different ($p=0.542$).

Data on the ward were available for 122 patients, among which 42 CPR events were performed in the emergency department on the day of admission (EM same day) and 12 patients admitted to the emergency department, the CPR event took place on later dates (EM later), 32 CPR events were carried out in PICU, 8 in NICU, 8 in open-heart surgery NICU (OH NICU), 5 in the cardiopulmonary ward, and 15 in the cardiac intensive care unit (CICU).

Data on the sex distribution of patients by ward are presented in table 1. Fisher's exact test showed a significant difference in sex distribution between EM same day and EM later groups (28 females and 14 males versus 3 females and 9 males, $p=0.012$). No other significant differences were detected among wards regarding sex distribution. Data on the mean age of the patients of the emergency department are summarized in table 1, with a mean age of 30±7 months for EM same day and 14±8 months for EM later. Mann-Whitney U test detected no difference in age distribution between EM same day and EM later groups ($p=0.272$).

Of 155 subjects for which data on the hour of CPR were available, 102 underwent CPR during the day and 53 at night. Table 2 demonstrates the distribution of CPR events by day versus night. For 149 of the subjects, data on the exact hour of CPR were available. Chi-square goodness of fit test comparing the frequency of the occurrence of CPR on two-hour time blocks yielded significant results ($p=0.041$), pointing to an uneven distribution of the frequency of occurrence of CPR across two-hour blocks, with dips at 0-2 a.m. and 12-2 p.m. and heights at 2-4 p.m. and 6-8 p.m. (representing 5, 6, 17 and 17 CPR events, respectively).

For 155 subjects, data regarding the shift on which CPR was performed was available. Of the CPR procedures, 32 (20.6%) were performed on the morning shift, 46 (29.7%) on the evening shift,

Table 1. Distribution of CPR Events by Age and Sex in Wards

		Age (months)		Sex					
		Mean	SE	Female		Male		Total	
				Number	%	Number	%	Number	%
Ward	EM same day	30	7	28	66.7%	14	33.3%	42	100.0%
	EM later	14	8	3	25.0%	9	75.0%	12	100.0%
	PICU	63	11	18	56.3%	14	43.8%	32	100.0%
	NICU	2	1	3	37.5%	5	62.5%	8	100.0%
	OH NICU	6	2	3	37.5%	5	62.5%	8	100.0%
	Card ward	16	11	3	60.0%	2	40.0%	5	100.0%
	CICU	4	1	7	46.7%	8	53.3%	15	100.0%
	Total	31	4	65	53.3%	57	46.7%	122	100.0%

EM= Emergency Department, PICU= Pediatric ICU, NICU= Neonatal ICU, OH NICU= Open Heart Surgery Neonatal ICU, Card Ward= Cardiopulmonary Ward, CICU= Cardiac ICU

Table 2. Distribution of CPR Events by Day versus Night in Wards

		Day/Night							
		Day		Night		Unknown		Total	
		Number	%	Number	%	Number	%	Number	%
Ward	EM same day	25	59.5%	14	33.3%	3	7.1%	42	100.0%
	EM later	7	58.3%	5	41.7%	0	0.0%	12	100.0%
	PICU	19	59.4%	9	28.1%	4	12.5%	32	100.0%
	NICU	4	50.0%	3	37.5%	1	12.5%	8	100.0%
	OH NICU	6	75.0%	1	12.5%	1	12.5%	8	100.0%
	Card ward	3	60.0%	2	40.0%	0	0.0%	5	100.0%
	CICU	8	53.3%	5	33.3%	2	13.3%	15	100.0%
	Total	72	59.0%	39	32.0%	11	9.0%	122	100.0%

EM= Emergency Department, PICU= Pediatric ICU, NICU= Neonatal ICU, OH NICU= Open Heart Surgery Neonatal ICU, Card Ward= Cardiopulmonary Ward, CICU= Cardiac ICU

and 77 (49.7%) on the night shift. The Chi-square goodness of fit test revealed an extremely significant difference in the number of CPRs performed on shifts (p=0.000). No significant difference was found in the frequency of occurrence of CPR on morning and evening shifts (p=0.113) through pairwise chi-square goodness of fit test, but the differences between morning and night shifts and also between evening and night shifts were extremely significant (p=0.000 and 0.005, respectively).

For 151 subjects, data were available about the day of the week on which CPR was performed. Of these patients, 115 underwent CPR on workdays and 36 on weekends or bridge days. Table 3 shows the distribution of CPR events by workday versus weekends and bridge days.

For 161 of the subjects, data on the outcome of CPR (survival versus death) was available. Of this number, 86 (53.4%) survived CPR, and 75 (46.6%) died. Among 73 females, 44 (60.3%) survived and 29 (39.7%) died, while of the 88 male subjects, 42 (47.7%) survived and 46 (52.3%) died. A chi-square

Table 3. Distribution of CPR Events by Workdays versus Weekends in Wards

		Workdays/ Weekends							
		Workdays		Weekends*		Unknown		Total	
		Number	%	Number	%	Number	%	Number	%
Ward	EM same day	31	73.8%	11	26.2%	0	0.0%	42	100.0%
	EM later	11	91.7%	1	8.3%	0	0.0%	12	100.0%
	PICU	22	68.8%	8	25.0%	2	6.3%	32	100.0%
	NICU	4	50.0%	4	50.0%	0	0.0%	8	100.0%
	OH NICU	7	87.5%	1	12.5%	0	0.0%	8	100.0%
	Card ward	4	80.0%	1	20.0%	0	0.0%	5	100.0%
	CICU	11	73.3%	2	13.3%	2	13.3%	15	100.0%
	Total	90	73.8%	28	23.0%	4	3.3%	122	100.0%

* Including "bridge days"
EM= Emergency Department, PICU= Pediatric ICU, NICU= Neonatal ICU, OH NICU= Open Heart Surgery Neonatal ICU, Card Ward= Cardiopulmonary Ward, CICU= Cardiac ICU

test of independence was calculated comparing the frequency of outcome in females and males. No significant relationship was found (p=0.112). Sex and survival appear to be independent variables in this setting. Data on age and outcome were available for 148 subjects. Among those who survived after CPR, the mean age was 27 months (SD=6), and among those who died, 35 months (SD=6). Independent samples Mann-Whitney test was not significant (p=0.333).

No significant difference was observed in outcome distribution between EM same day and EM later groups (27 survivals and 12 deaths versus 5 survivals and 6 deaths, p=0.172). However, the difference between EM same day and PICU groups was extremely significant (27 survivals and 12 deaths versus 10 survivals and 22 deaths, p=0.002). There were also significant differences between EM same day and NICU groups (p=0.005) and EM same day and CICU groups (p=0.016), but not among PICU, NICU, and CICU groups. Table 4 depicts that the outcome Pearson's test detected an extremely significant correlation between ward and outcome (p=0.000). This result was confirmed in logistic regression models after taking into account potential

Table 4. Outcome of CPR by Ward

		Outcome							
		Survived		Died		Unknown		Total	
		Number	%	Number	%	Number	%	Number	%
Ward	EM same day	27	64.3%	12	28.6%	3	7.1%	42	100.0%
	EM later	5	41.7%	6	50.0%	1	8.3%	12	100.0%
	PICU	10	31.3%	22	68.8%	0	0.0%	32	100.0%
	NICU	1	12.5%	7	87.5%	0	0.0%	8	100.0%
	OH NICU	0	0.0%	7	87.5%	1	12.5%	8	100.0%
	Card ward	3	60.0%	2	40.0%	0	0.0%	5	100.0%
	CICU	3	20.0%	9	60.0%	3	20.0%	15	100.0%
	Total	49	40.2%	65	53.3%	8	6.6%	122	100.0%

EM= Emergency Department, PICU= Pediatric ICU, NICU= Neonatal ICU, OH NICU= Open Heart Surgery Neonatal ICU, Card Ward= Cardiopulmonary Ward, CICU= Cardiac ICU confounding factors.

For 144 subjects, data were available on the day of the week in which the CPR event took place. During the day, 96 CPR events were performed, with 52 (54.2%) survivals and 44 (45.8%) deaths. During the night time, 48 procedures were performed, with an equal number of survivals and deaths. The Chi-square test of independence detected no significant difference in outcome frequency distributions between day and night (p=0.637).

Data on variables of outcome and the shift of CPR were available for 144 subjects. Of 31 CPR events in the morning shift, 21 (67.7%) survived, and 10 (32.3%) deceased. Of 43 CPR events in the evening shift, 18 (41.9%) resulted in survival, and 25 (58.1%) in death. On the night shift, 70 CPR procedures yielded 37 (52.9%) survivals and 33 (47.1%) deaths. The Chi-square test of independence revealed significant differences in the outcome between morning and evening shifts (p=0.028), but there was no significant difference between morning and night shifts (p=0.163) or between evening and night shifts (p=0.256).

For 142 subjects, data were available on the day of the week in which the CPR event took place. In workdays, 108 CPR events were performed, with 53 (49.1%) survivals and 55 (50.9%) deaths. At weekends, including bridge days, 34 procedures were performed, with equal numbers of survivals and deaths. The Chi-square test of independence did not detect a significant difference in outcome frequency distributions between workdays and weekends (p=0.925).

Discussion

No relationship was discovered between the age of the patients and survival after CPR. This finding is in contrast with the results of Meaney *et al*, which reported better survival from pediatric ICU cardiac arrests in newborns and infants than in older children (7). Furthermore, there was no significant difference in the sex distribution of the patients and no relationship between sex and survival after CPR.

There was a significant difference between the EM same day and EM later groups in terms of sex distribution. In the former group, the number of female patients was twice the number of males, while in the latter group, the ratio of female to male was 1 to 3. It should also be noted that there was a marked difference between CPR survival rates of EM same-day and EM later groups (27 survivals to 12 deaths versus 5 survivals and 6 deaths, respectively); however, this difference reached the statistical significance level.

In a wider investigation of the wards, there were significant differences among them in terms of the mean age of the patients undergoing CPR. Given the context (*e.g.*, PICU and NICU), such differences are to be expected. However, no significant differences were detected among wards regarding sex distribution, apart from between EM same day and EM later. In terms of survival after CPR, unlike EM the same day that showed a 69.2% post-CPR survival, survival rates of ICU CPRs were low, ranging from 31.3% in PICU to 0% in OH ICU. The low survival rate of intensive care units can be justified by the critical condition of the patients, especially for the open-heart surgery ICU, which receives the most critical patients, as our hospital is the only referral pediatrics hospital in the country with OH ICU. Significant differences were detected between EM same day and the three major ICUs of the hospital, PICU, NICU, and CICU, while no significant differences were observed between these three ICUs.

These variations can reflect differences between the diseases and conditions covered in different settings. Other studies have reported variations in survival rate after in-hospital CPR in pediatric patients in relation to the disease type. Ortmann *et al* found a significantly better survival rate after CPR in children with surgical-cardiac diseases than in children with medical-cardiac diseases and noncardiac disease (5), while among pediatric patients with cardiovascular disease, Lowry *et al* observed decreased survival in single-ventricle patients and increased survival in recent cardiac surgery patients after CPR (6).

In the present study, the immediate post-CPR outcome in PICU was 10 survivals to 22 deaths, revealing a 31.3% survival rate. In their study of multidisciplinary pediatric intensive care unit, de Mos *et al* found an immediate post-CPR survival rate of 82% (75 survivals); notably, the rate of survival dropped to 25% (23 survivals) by the time of survival discharge (4). The reasons for this stark difference between immediate post-CPR survivals rate should be studied in more detail and complemented by data on post-CPR survival rates at the time of discharge.

The results showed an uneven distribution of CPR events in 24 *hr* divided into twelve, 2-*hr* blocks to facilitate the study, with significant dips at 0-2 am and 12-2 p.m. and rises at 2-4 p.m. and 6-8 p.m.. Furthermore, significant differences were observed in the frequency of CPRs between morning and evening shifts and also night and evening shifts, with the number of CPR events in the evening shifts being significantly higher. No such difference was observed between the morning and night shifts. Interestingly, the 2-4 p.m. rise in the frequency of CPR corresponds to the beginning of the evening shift. The second rise in CPR events 6-8 p.m., too, occurs during this shift.

In terms of the outcome, there was a significant difference between morning and evening shifts, with relatively more CPRs in the evening shift ending in death than in the morning shift (18 survivals and 25 deaths in the evening shift versus 21 survivals and 10 deaths in the morning shift). The two rises in the number of CPR events, 2-4 p.m. and 6-8 p.m., both occurring in the evening shift, correspond to the highest ratios of death to survival throughout the 24 hours (11 deaths to 6 survivals and 10 deaths to 7 survivals, respectively). Overall, wide variation is seen in the ratio of survival to death after CPR among 2-hour periods; for example, the ratio of survival to death in the 2-hour period from 10 a.m. to noon is 1 to 6. However, due to the small number of CPR events in some 2-hour periods in the present study, further studies with larger sample sizes are needed to clarify the significance of this variation. In the present study, no significant differences were observed between morning and night shifts or evening and night shifts, and also between day and night in terms of the CPR outcome. Outcome frequency distributions were not significantly between workdays versus weekends.

Bhanji *et al* reported a higher mortality rate following night-time CPRs compared to CPR events occurring during days and evenings, but no significant difference between post-CPR mortality rates in weekdays versus weekends (16). In contrast to the study by Bhanji *et al*, the present study found a higher post-CPR mortality rate in the evenings. However, like their findings, the present study detected no difference between weekdays and weekends in terms of post-CPR survival, a finding that would argue against a lower level of readiness among the emergency department and ICU staff at weekends. In contrast to the study by Bhanji *et al*, the present study found a higher post-CPR mortality rate in the evenings.

The differences observed in various studies can be justified due to different locations, crowdedness of hospitals, different specialties in the hospital and the level of training and the number of personnel. Our hospital is the main referral center of the country for the most critical patients in all fields of pediatrics. That is why in some departments, the survival rates were different from other studies. In the ICUs not all successful CPRs were registered, but all the unsuccessful ones were reported and followed. Improving the quality of reporting and registering of CPR events and other documentation should also be considered.

We recommend that every medical center should conduct studies to find out its hidden weaknesses in order to increase the quality of cardiopulmonary resuscitation.

Limitations of the study

Some of the CPR records were not registered properly due to the limited number of subjects, and some of the statistical analyses failed to render conclusive results. Further studies with larger sample sizes would impart the necessary statistical power to the tests and furnish a clearer picture of the subject under study.

Conclusion

The present study showed a significantly higher occurrence of CPR at 2-4 p.m. and 6-8 p.m., corresponding to the beginning and end of the evening shift and a higher rate of post-CPR death in this shift. The results of this study can help improve resource allocation and prepare the staff for CPR performance and post-CPR care of pediatric patients during the times of high CPR load and high risk of post-CPR mortality.

Conflict of Interest

Nothing to declare.

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