DOI Number: 10.5958/0974-9357.2020.00015.X

Predictors of Mortality in Pediatrics Cardiopulmonary Resuscitation: Observational Multicenter Study

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Abstract

Purpose: This study aimed to identify predictors of mortality related to the quality of CPR, victims' pre-CPR characteristics, and the resuscitation characteristics.

Design and Method: A descriptive observational design with a non-active approach was used. Data collectors observed the implementation of CPR then recorded the parameters of interest against a pre-structured checklist. A total of 242 CPR events were observed. The study took place in three medical centers in Jordan.

Results: The study showed that victims whose CPR took place in the emergency room and those admitted with cardiac and respiratory diseases were more likely to resume spontaneous breathing and circulation.

Conclusion: Early identification of patients at high risk for mortality would help to reduce the rate of mortality through quick response and proper resuscitation.

Keywords: *CPR; pediatric; mortality; predictors.*

Introduction

Cardiopulmonary resuscitation (CPR) aims to restore circulation and breathing in order to increase the chance of survival; however, its outcomes are not fully predictable. Despite advances in the prevention and treatment of cardiopulmonary arrest in children, the rate of mortality is significantly high, especially in developing countries [1,2]. Studies have reported mortality rates of from 15% up to 50% of the total number of pediatric admissions[3,4]. This represents a major challenge for healthcare providers and is a significant social and economic burden.

Mortality from CPR has decreased dramatically over the past two decades, from 85% to 50% [3]. The factors contributing to this are multidimensional and include but are not limited to the improvement in the quality of CPR and the application of many approaches to improve the quality of care delivered to pediatric patients; however, there is evidence of great variation in the rate of mortality across the world, meaning that more lives could be saved.

Studies reported a significant increase in the rate of post-CPR mortality in developing countries in comparison with the western world[5,6]. One study in Saudi Arabia reported a rate of mortality of 50% [7], and another of immediate post-CPR mortality of 36% and 70% at discharge [8]. A study in Iran reported a rate of 37% [9], while one in Malawi found spontaneous circulation in only 6% of victims (N=135) [10]. In the other hand, a

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study in the United States (N=164) reported a rate of 10% mortality [11] and another 7 deaths/1000 victims [12].

Several pre-arrest and resuscitation factors have been investigated to evaluate their effect on mortality, including the type of arrhythmia, duration of CPR, use of vasoactive drugs, and use of a mechanical ventilator. However, there is still imprecision in the prediction of mortality following CPR due to the large number of etiologies and the diversity of patients. Successful prediction and early management of cardiopulmonary arrest are crucial to prevent mortality.

This study investigated the predictors of mortality in pediatric CPR. Potential predictors considered were the quality of CPR, victims' pre-CPR characteristics (gender, ward, type of arrhythmia that necessitated CPR, diagnosis at admission), and the resuscitation characteristics (onset and duration of CPR).

Method

Design: This study used a descriptive observational design. Data collectors observed the application of CPR and documented the procedures without taking part themselves. Some of the variables were obtained from the patients' files.

Setting: The study was conducted in three hospitals located in three major cities in Jordan, each receiving an average of 1,000 admissions a month. Observations were conducted on several wards including emergency room, medical and surgical floors, and intensive care units. The average number of beds in these departments was 10. The selection of hospitals was based on the availability of ethical permission and a large bed capacity of more than 500.

Sample and sample's characteristics: Sample size for this study was calculated using G* Power software version 3 [13]. Based on an estimated medium effect size of 0.15, power of 0.95, and a statistical significance 0.05, the required sample size to run binary logistic regression tests was 161. 242 CPR cases were obtained to increase confidence in the results.

Eligible participants were any CPR victim aged from 1 month to 14 years, with a cardiac or pulmonary arrest witnessed by the observers of this study. Exclusion criteria were unwitnessed CPR (that is, occurring before arrival at hospital) and adult CPR patients.

Instrument: An observational checklist was created based on the updated CPR evidence-based guidelines from the American Heart Association [14]. The checklist contained two parts. Part one covered general items including gender, ward, type of arrhythmia that necessitated CPR, diagnosis at admission, and onset and duration of CPR. Part two was a 20-item checklist that measured the quality of CPR with three options per item: "not done" deserved no credit, "done but not completely or not accurately" was awarded one mark, and "done completely and accurately" two marks. Higher scores in part two indicated a higher quality of CPR. During the observation, the observer recorded "not done" if the CPR team failed to apply the item of interest based on the updated AHA guidelines. If the CPR team demonstrated an action that had some value but was inconsistent with the guidelines, the observer recorded "done but not completely," and if the team demonstrated an action that was consistent with the guidelines, "done completely and accurately." The maximum score was 40 and the minimum 0, the higher score indicating a higher quality of CPR. A panel of experts participated in the evaluation of the validity and reliability of the instrument. The panel approved the content validity of the instrument.

A pilot study with 10 CPR events was conducted to evaluate the inter-observer reliability. The test was conducted by having three observers score the quality of CPR performed by the rescuers. The instrument showed very good reliability with an interclass correlation coefficient of 0.79.

Data collection procedures: The study was advertised in the participating hospitals and followed by a presentation that explained the goals and procedures of the study. Hospital staff were informed that they would be observed during CPR and their performance as a team would be evaluated according to a pre-structured observation sheet. The staff were also informed that observations would be overt and they would be allowed to see the completed instrument for every CPR if requested, their acceptance to being observed during CPR considered as consent to participate.

Providers of basic life support and advanced cardiac life support authorized by the American Heart Association were recruited for data collection. They were not staff of the participating hospitals. They attended a brief training course on how to complete the study's instrument. They waited in the participating hospitals for a CPR call, and then observed the CPR procedures and completed part two of the observational sheet (quality

of CPR). Part one (general items) was later completed from patients' records. CPR in this study was defined as any respiratory or cardiac arrest with an absence of spontaneous breathing and/or pulse. Two data collectors were assigned to each department in each hospital, to cover both day and night shifts. The primary outcome was the mortality rate at the end of CPR. Return of spontaneous circulation and breathing was considered the criterion for survival. The study was conducted over a one-year period from January 2018 to January 2019.

Statistical analysis: The Statistical Package for Social Science (SPSS) version 21 [15] was used to analyze the data. Cleaning and screening were first conducted, then the frequencies of the variables explored. Scores for the quality of CPR were calculated for each CPR event. Assumptions of logistic regression were tested, and none was found to be violated. The categorical variables "ward" and " diagnosis at admission" were dummy coded. For the former, the neuro ICU was selected as a reference category and for the latter "others." Logistic regression was conducted to assess the influence of the variables on mortality. The model contained the following independent variables: onset of CPR, quality of CPR score, type of arrhythmia, duration of CPR, gender of CPR victim, ward, and diagnosis of CPR victim at admission. The dependent variable was CPR result (mortality vs. return of spontaneous circulation and breathing) at the end of CPR.

Ethical Issues: This study was granted ethical permission by the institutional review boards of the principal investigator's university and the participating hospitals. A request to waive informed consent was approved as the study had minimal risk and could not be conducted without the waiver. Confidentiality was maintained throughout the whole study. No information that might have led to the CPR providers' identity was sought. CPR victims' personal data was deleted from the final data file at the end of the study. Data were stored on the principal investigator's personal laptop. Hardcopy materials were shredded appropriately.

Results

242 CPR events were analyzed. Nearly a third of the victims had respiratory arrest. Almost two-thirds of the victims died (147 out of 242). Of those who resumed spontaneous circulation 61, were male of the victims, 234 (98%) were under two years old. The mean onset of CPR was 13 seconds and the mean duration 16 minutes. The mean duration of CPR for the victims who survived was 13 minutes. Almost half the participants were on a mechanical ventilator at the time of CPR. All victims received at least one dose of adrenaline (Table 1). The mean score for the quality of CPR was 28.8. Nearly four-fifths of the CPR were given a quality score above 20 (198 out of 242).

The logistic regression model with the independent variables gender, ward, type of arrhythmia that necessitated CPR, diagnosis at admission, onset of CPR, duration of CPR, and quality of CPR was significant: $\chi^2(8) = 17.867$, p=0.02. The model explained 45% of the variance in mortality and correctly classified 81% of the cases. The ward in which the CPR took place and diagnosis at admission were the most significant predictors of mortality. CPR which took place in the emergency room was 26% less likely to end up with death than that in the neuro ICU. Likewise, victims who were admitted with cardiac and respiratory diseases were respectively 21% and 29% less likely to die in CPR than those admitted with other sorts of illness. The onset, quality, and duration of CPR were statistically significant; however the odd ratio for each was very small and it was unlikely to have a clinical effect on mortality (Table 2).

Table 1: Participants' Characteristics

Variable	N=242 n (%)
Gender	
Female	109(45%)
Male	133(55%)
Ward	
Emergency Unit	95(39%)
Pediatric Intensive Care Unite	50(21%)
Medical/Surgical Floor	59(24%)
Neuro Intensive Care Unite	38(16%)
Arrhythmia that Initiated CPR**	
Ventricular Tachycardia	60(25%)
ventricular Fibrillation	98(40%)
A Systole	84(35%)
Diagnosis at Admission	
Respiratory Diseases	72(30%)
Cardiac Diseases	45(19%)
Neurologic and Head Injury	47(19%)
Others*	78(32%)

*: Poisoning, snake bite, scorpion sting, blood disorder, acid base disturbance, renal diseases, birth related and developmental abnormalities, and gastrointestinal disturbances

**: Cardiopulmonary resuscitation

Table 2: Predictors of mortality in pediatric CPR

Variable	B	p-value	Odds Ratio	95% CI for Odds Ratio	
Onset of CPR***	0.69	0.00	1.07*	1.01	1.11
Quality of CPR	-0.06	0.00	0.94*	0.90	0.98
Type of arrhythmia	-0.70	0.11	0.55	0.26	1.15
Duration of CPR	0.12	0.00	1.13*	1.07	1.19
Gender	-0.54	0.10	0.64	0.33	1.1
Ward		0.00			
Emergency unit	-1.60	0.00	0.26*	0.09	0.78
Pediatric intensive care unite	-0.65	0.26	0.52	0.16	1.63
Medical/surgical floor	-0.11	0.84	0.89	0.28	2.81
Neuro intensive care unite			1**		
Diagnosis at admission		.047			
Respiratory diseases	-1.75	0.00	0.29*	0.12	0.72
Cardiac diseases	-2.18	0.01	0.21*	0.08	0.53
Neurologic and head injury	-0.91	0.29	0.40	0.07	2.21
Others			1**		

*: $p < 0.05$, **: Reference category, ***: Cardiopulmonary resuscitation

Discussion

This study investigated predictors of mortality in pediatric CPR. Potential predictors investigated included quality of CPR, victims' pre-CPR characteristics and resuscitation characteristics. We found that CPR victims who had had their resuscitation in the emergency room were less likely to die than those in the other wards. Likewise, the odds of death among victims admitted with respiratory or cardiac diseases were significantly lower than those of patients who had different sorts of illness. Duration, onset, and quality of CPR were found to be statistically significant yet with minimal clinical significance.

Our findings agreed with other studies, that several pre-arrest characteristics influence the victim's chance of survival. For example, those admitted with heart disease had a lower mortality rate than those with other diagnoses[11,16]. Rathore, Bansal, Singhi, Singhi, Muralidharan[6] reported sepsis at admission as the major predictor of mortality following pediatric CPR.

On the other hand, our findings contradicted other studies which reported no difference in mortality among victims admitted with heart disease [17] (N=150) or respiratory disease[11] (N=164) in comparison with other diagnoses; however these studies recommended replication with larger sample sizes.

Our findings contradicted those from other studies which reported a lower rate of mortality among patients in the pediatric intensive care unit (PICU) [5,16]. In our study, the emergency department showed a lower rate than in other departments. Our finding could be explained by the fact that children with critical illness are usually treated in the emergency room rather than the PICU because of the unavailability of beds in the latter. This situation is common in developing countries with limited resources [6].

Our study had some limitations; although it was adequately resourced, it failed the capture the effect of some major factors. It would be useful replicate it with a larger sample size to help uncover the influence of the duration, quality and onset of CPR on mortality. Moreover, this study missed some important variables such as the administration of other CPR medications including sodium bicarbonate and calcium gluconate, which might have affected the reliability of the findings. In addition, selection of CPR events was not random and might entail some bias. Future studies are recommended to use random sampling to improve the reliability of the findings. Finally, the primary indicator in this study was the return of spontaneous circulation and breathing. It would be helpful for future research to consider other criteria, such as sustained return of circulation and breathing and discharge from hospital.

Conclusion

Predictors of mortality in pediatric CPR are not fully understood due to the wide variety of factors that affect victims. The effect of diagnosis at admission and the ward in which the CPR takes place were the most significant factors influencing the rate of mortality. Although the effect of the quality, duration, and onset of CPR was known from previous studies, this effect could not be captured in ours. Replication of our study may reveal the effect of such factors.

Funding: This study was funded by a grant from Al albayt University, Jordan

Acknowledgment: This is our own work.

Conflict of Interests: The authors declare that there are no conflict of interests relevant to this work.

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