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Pediatric cardiopulmonary resuscitation: comparison between emergency department and inpatients setting at a tertiary academic hospital in Oman

Abstract

Objective: The aim of this study was to compare cardiopulmonary resuscitation (CPR) between emergency department (ED) and inpatients setting at Sultan Qaboos University Hospital (SQUH).

Methods: The study was a retrospective cohort chart review of pediatric CPR at Sultan Qaboos University Hospital (SQUH) from January 2012 till August 2017. The CPR sheets were reviewed for four main variables: patient related, event related, treatment and outcomes.

Results: A total of 83 cases were included, 48 males (58%) and 35 females (42%). Two Thirds of the patients (n=56) were in-patient; whereas one third of cases were from ED (n=27). Overall, most common cause for arrest that accounted 73.5% (n=61) was due to respiratory arrest. Events were more common in younger age group with 50% in less than 1 year (n=41). Bradycardia with hypo-perfusion represented most of arrest type 65% (n=54) followed by asystole 31% (n=26). Only 10% of patient survived to discharge (n=8). In comparison, 89% of ED arrest were unwitnessed. On the other hand, PICU and ward arrests predominantly were monitored 98% (n=55). ED patients' survival appeared better at 19.2% (n=5) within 24hrs post arrest and 11.5% (n=3) within 1-year in comparison to PICU/ Ward of 8.9% (n=5) survival within 24hrs and 1-year post event yet it was not statistically significant.

Conclusion: The survival outcome in resuscitation was almost similar between ED & In-patient setting (PICU/wards) cardiopulmonary arrests despite having few significant differences based on variables. Overall, 10% of patients survived to discharge and higher survival rates are associated with duration of CPR less than 20 minutes . Intraosseous route is underutilized and should be applied earlier especially in ED to prevent delay in administration of resuscitation medications.

Keywords: Pediatric cardiopulmonary resuscitation, Neurological outcome, Emergency department resuscitation, In hospital setting

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Introduction

Pediatric cardiopulmonary resuscitation (CPR) is a rare encounter compare to adult CPR and usually account for only 2% of total pediatric admission and more often seen in pediatric intensive care unit (PICU) admission. Among in-hospital locations where CPR is performed, the Emergency department (ED) constituted a minority of such events, comprising 9-11% of all in-hospital CPR events in both adult and pediatric patients.[1-3] Outcomes among patients receiving CPR during an ED visit are likely influenced in a more complex manner by prehospital care, premorbid medical conditions, and variances in care processes in other in-hospital settings. Although previously published studies from American Heart Association Get with Guidelines–Resuscitation Registry on outcomes from pediatric CPR in the ED showed much poorer survival compared to adults, on the other hand, outcomes from pediatric CPR displayed twice as likely to survive to hospital discharge when compared to ICU or ward. Recent studies demonstrated the outcomes from cardiac arrest occurring in emergency department do not differ significantly between children & adults.[1-4] In our study we sought to analyze whether pediatric CPR show better or worse or similar outcomes between ED & other in-hospital locations (PICU &/or wards). Reviewing the literature, there were no published studies comparing outcomes of children who received CPR in ED and other in-hospital locations. Studies have shown CPR although can be satisfactorily performed by highly trained professionals in emergency department, still not optimally done when it comes to adhering to the updated resuscitation guidelines.[5]

Our study was conducted in Sultan Qaboos University Hospital (SQUH), one of Oman's leading academic and tertiary care hospital in Oman. The motive behind selecting & comparing between emergency department & in-patient setting is because nearly all pediatric CPR are held in these settings & were carried by set of different team members respectively. Our Emergency department handles both adult & pediatric emergency cases and our team consists of highly trained mostly board-certified emergency physicians who undergoes continuous training for quality improvement in cardiopulmonary resuscitation and post resuscitation care both in adults & pediatrics. When a Pediatric cardiac arrest occurs in ED, it is managed by members comprising of Emergency physicians, Post graduate residents, Emergency nurses & Paramedics while in Pediatric Intensive Care Unit (PICU) & other wards, pediatric resuscitation is handled by Pediatric Cardiac Arrest Code Team comprising of PICU intensivist, pediatrician, Post graduate residents, anesthetist & staff nurses. In SQUH, pediatric cardiopulmonary resuscitation is based on Pediatric Advanced Life Support (PALS) under American Heart

Association. The health care providers in ED including nurses and physicians involved in pediatric resuscitations were expected to be PALS qualified. On reviewing the status, all ED physicians are PALS certified but only less than 50% of ED & ward nurses are PALS certified. On the other hand, all the PICU physicians and nurses are PALS certified. The information on pediatric arrests that occur either in ED or PICU or wards in SQUH are maintained in manual CPR sheets & documented in clinical notes electronically. The filled CPR forms are scanned and saved in patients' record in track-care system.

Most of the published studies in the literature on pediatric CPR were done by reviewing overall pediatric arrests combining data together from both ED and inpatients settings.[1-5] However there were no studies found in literature conducted to analyze comparison in pediatric CPR within hospital locations namely ED & inpatients setting (PICU & wards). The primary aim of our study is to compare management and outcome of pediatric CPR between ED & in-hospital settings based on multiple variables. The Secondary outcome would be to describe the survival outcome & predictors of survival in general. Utstein guidelines, a well described criterion in reporting CPR will be used in this study, where four different sets of variables are assessed including hospital, patients, arrest/event and outcome.[2,3]

Methods

Study design

The study was retrospective cohort chart review study of pediatric CPR cases that was recorded at Sultan Qaboos University Hospital, Muscat Oman, for five-and-half-year duration, during the periods from January 2012 till August 2017. Data collection prior to 2012 was difficult due to absence computerized data record. The data was collected on pediatric CPR occurred in pediatric emergency department as well as Inpatient settings, namely pediatric intensive care unit (PICU) & wards.

Study objectives

The primary objective of our study is to compare pediatric CPR between ED & in-hospital settings based on multiple variables.

The secondary objective of the study is to describe the survival outcomes of pediatric arrest patients.

Study setting & population

The CPR sheets were collected and reviewed for multiple variables that were divided into patient, event, treatment, and outcome variables. All pediatric cardiac arrests occurred in our hospital were included irrespective of nationalities with following inclusion and exclusion criteria.

Inclusion and exclusion criteria:

Inclusion criteria:

a) Patients with age less than 13 years

b) Fitting the definition of cardiac arrest, so the patients will be included if they have experienced a clinical event marked by cardiac arrest or critical bradycardia or hypoperfusion treated with chest compressions

c) Filled CPR forms

Exclusion criteria:

a) Neonates who had resuscitation in delivery room or immediately after delivery

b) Resuscitation due to trauma

c) Do not resuscitate (DNR) labeled patients

d) Patients of unknown age

e) Duplicate cases (each case will be included only once for the first arrest)

f) If no CPR documentation was found

Study definitions[3,6]

i. Cardiopulmonary resuscitation (CPR): chest compressions & assisted ventilations provided because of cardiac arrest or because of bradycardia with poor perfusion.

ii. Cardiac arrest: cessation of cardiac mechanical activity, determined by inability to palpate central pulse, unresponsiveness apnea.

iii. Bradycardia with poor perfusion: heart rate < 60beat per min with grossly inadequate perfusion despite support with oxygen & effective ventilation.

iv. Pulseless electrical activity: cardiac arrest in which the monitor or electrocardiogram shows a heart rhythm that does not produce a pulse

v. Sustained return of spontaneous circulation (ROSC): return of spontaneous circulation after resuscitation lasting more than 20 minutes.

vi. Event duration: the time interval from the delivery of the first chest compression until either the time of sustained ROSC (lasting >20 min) or the time when resuscitation efforts were terminated.

vii. Weekend events: defined as events occurring during the time interval from 15:00 pm Thursday to 6:59 AM Sunday.

viii. Working days events: defines as events occurring duration of days from Sunday 07:00 till 14:59 pm on Thursday.

ix. Time of event: defined as morning time from: 07:00 till 14:59pm, evening from: 15:00-22.59, night: 23:00-06.59 am

x. Respiratory support: presence of one or more of the following: assisted ventilation, mechanical ventilation, or inhaled nitric oxide

xi. Cardiovascular support: presence of any vasoactive infusion and/or any antiarrhythmic infusion

xii. Monitored arrest: presence of one or more of the following: ECG, pulse oximetry, or apnea monitor. Witnessed Arrest : Direct observation of patients suffering cardiac arrest.

xiii. CPR for bradycardia: defined as being present if the initial rhythm was bradycardia and the initial pulse status was labeled as 'pulse present'.

xiv. Advanced airway: defined in one of three categories: advanced airway already in place, airway placement attempted during the event, or no attempt at airway placement during the event

xv. Initial shockable rhythm: an event with a first documented rhythm of cardiac arrest is pulseless ventricular tachycardia or ventricular fibrillation

xvi. Subsequent ventricular fibrillation (VF): an event where the initial rhythm was not shockable (asystole, PEA, bradycardia) but VF/pulseless VT occurred at some point

xvii. Pediatric cerebral performance category (PCPC): it a neurological outcome scale used by Utstein guidelines and divided into 6 categories, 1, normal, 2, mild disability; category 3, moderate disability; category 4, severe disability; category 5, coma/vegetative state; and category 6, death.

xviii. Inpatients arrest – pediatric patients who had Cardiopulmonary Resuscitation in any in-hospital areas other than emergency department - such as in PICU, wards, OPD, OT, Daycare etc.

Variables

Patient variables:

a) Age,

b) Gender

c) Weight

d) Nationality

e) Pre-existing illness: cardiac, respiratory, others (metabolic, hematological, oncological, neurological and developmental)

f) Previous cardiac surgery

g) Chronic medication

h) Pre-arrest neurological status

i) Pre-event cardiovascular support,

j) Pre-event respiratory support

Event variable:

a) Site – ED, PICU, pediatric wards, others (Operational theater (OT) , day care unit, pediatric outpatient department (OPD) , recovery room)

b) Immediate cause (respiratory/cardiac)

c) Monitor /witness status of arrest

d) Initial arrest – PEA /asystole, shockable (VF, pulseless VT) brady with hypoperfusion

e) Subsequent shockable rhythm pulseless VT/VF

f) Weekend/working day

g) Time of arrest

Treatment variables:

a) Duration of CPR in minutes

b) Number of actual epinephrine doses given

c) Number of expected minimum epinephrine doses (total duration of CPR divided by 5 as the epinephrine dose should be treated every 3-5 minutes in CPR)

d) Time to first epinephrine dose

e) Time to first defibrillation in shockable rhythm

f) Dose of defibrillation

g) Total number of defibrillation

h) Invasive airway

i) IV/IO/CVC

j) Sodium bicarbonate

k) Calcium gluconate

l) Atropine

m) Amiodarone

Outcome variables:

a) Sustained return of spontaneous circulation (ROSC)

b) Survival to admission

c) Survived 24 hours

d) Survival to discharge

e) Survival at 1 year follow up (Follow up will be done for patients who survived to discharged by reviewing their medical records if they have any visit to our hospital after discharged post arrest)

f) Neurological outcome using pediatric cerebral performance category (PCPC).

Data collection and analysis

Ethical approval was obtained from Ethical committee before retrieving patient records. A data collection sheet was used to collect the data from enrolled patients. The primary investigator has reviewed the first 30 patients' data to ensure the quality of data collection. All variables were summarized descriptively. Univariate analysis was done between ED pediatric resuscitation and Inpatients resuscitation looking at event, and treatment characteristic using chi square analysis for categorical variables and nonparametric (Wilcoxon rank-sum) testing for continuous variables. Multivariable logistic regression was used to examine the effect on survival outcomes. SPSS version 19 was used for data analysis.

Results

110 cases were reviewed and only 83 cases met the inclusion criteria (Figure 1). Figure 2 illustrate incidence of pediatric cardiac arrest over five- and half-years in both setting. The patients variables in both setting are described in Table 1. Males represented 58% (n=48). Inpatients cardiac arrests represented 67% (n=56), whereas 32.9 % (n=27) were from ED. 96% (n=80) patients were Omani nationals. 50% (n=41) of patients were less than 1 year. Pre-existing conditions were present in almost half of children in our study (66%, n=55)., 71% (n=35) of patients were on respiratory support and 63.6% (n=39) were on cardiac support prior to cardiac arrests. 61.4% (n= 51) were on chronic medications.

In comparison between the two setting in patients variables, the following were found to be significant. Preexisting illness were found in 78% of inpatients group, while 53.8% of ED group were previously healthy (p value 0.006). All of these patients who were on pre-event cardiac and respiratory support were in the inpatients setting while none of the ED patients were on pre-event support. (p value <0.001). Table 2 describes event variables in both setting. Respiratory causes were the main cause for pediatric arrest accounted for 73.5% (n=61), while the rest were cardiac. Bradycardia with hypo-perfusion represented majority of arrests rhythm 65% (n=54) followed by asystole 31% (n=26). 69.8 (n=58) of arrest were monitored/witnessed.

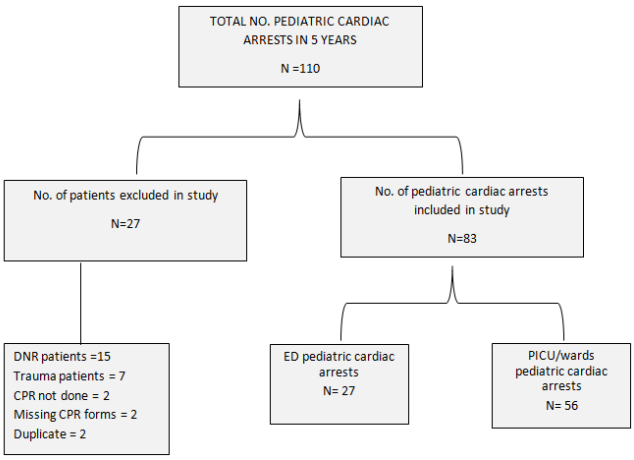

Figure 1 Study Flowchart.

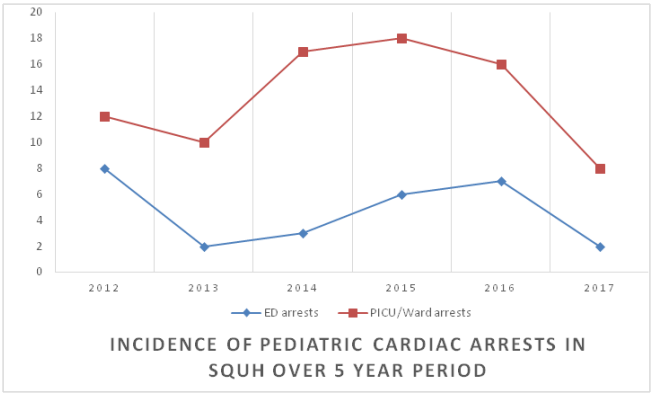

Figure 2 Incidence of Pediatric cardiac arrests in SQUH – 2012-2017.

Majority of arrests occurred during weekdays 66.8% (n=55) while 33.2% (n=28) of arrests occurred in weekends. Most of the arrest 66.6% (n=57) occurred during evening and night hours. In comparison between both setting, 89% (n=24) of arrests arrived to ED were unmonitored and/or unwitnessed compare to inpatients setting (p value <0.001). Figure 3 illustrate the initial rhythm in both groups being asystole in 81.5% (n=22) of ED cases compared to inpatient setting were bradycardia with hypoperfusion represented 87.5% (n=49) (p value<0.001). Table 3 describes treatment variables between the two settings. 54.2% (n=45) of patients had CPR less than 20 minutes. Only 9.6% (n=8) had defibrillation during CPR. Endotracheal intubation was performed in 91% (n=76) of patients. Central line were used in 50% (n=46) of the patients, where intra-osseous were used only in 14.4% (n=12). Sodium Bicarbonate was given in 61 (73.4%) patients, 16 (19.2%) patients received calcium gluconate, and 7 (8.4%) received atropine. Only 14.4% (n=12) achieved sustained ROSC.

In comparison between the two settings, 63% (n=17) of cases in ED had CPR for less than 20 minutes compare to 50% (n=28) in the in-patient. Only 84% (n=21) in ED were intubated while 98.2% (n=55) were intubated in in-patient group (p value 0.030). Intravenous line were used in 59.3% (n=16) in ED group compare to 20% (n=11) in in-patient, where intraosseous was used in 33.3% (n=9) compared to 5.5 % (n=3) in in-patient and central lines were predominantly used in in-patient group with 74.5% (n=41), (p value <0.001). Table 4 shows comparison of treatment covariables between two settings. The time for first dose of epinephrine was at a median of 4 minutes in ED compared to zero minutes in In-patient setting (p value of <0.001). There was no significant difference between number of defibrillation and duration of CPR given between two groups.

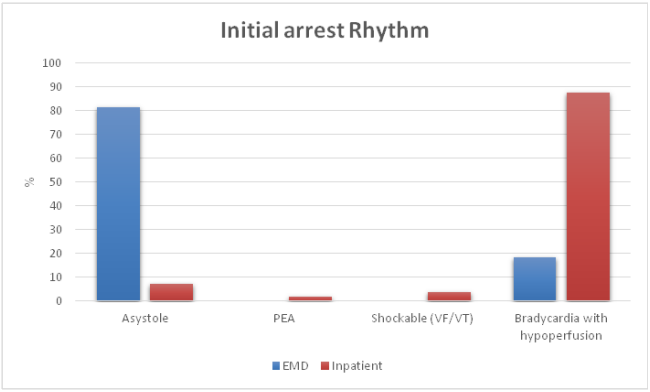

Figure 3 Comparison of initial event between EMD & Inpatient groups.

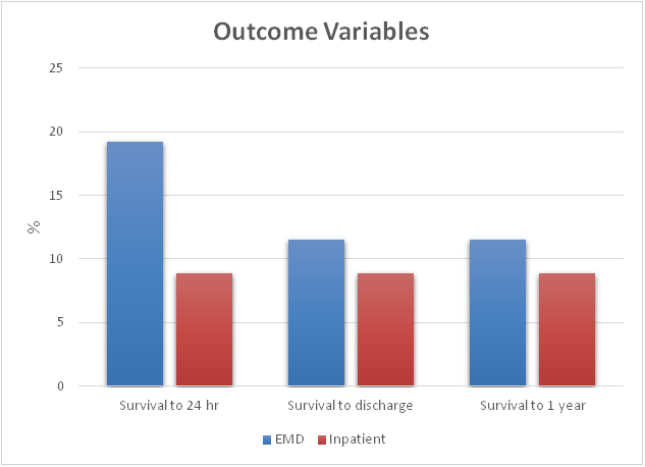

Figure 4 Comparison of survival outcome. variables between ED & Inpatient setting.

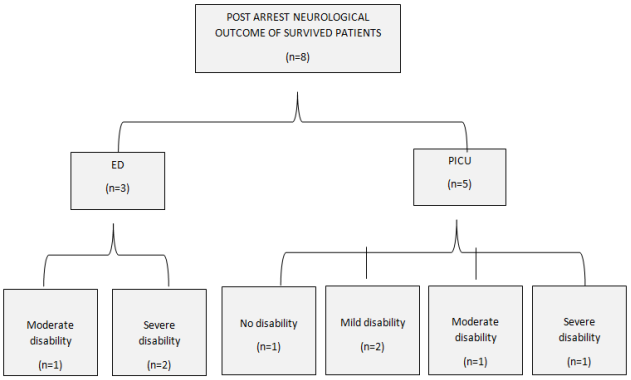

Figure 5 Post-Arrest Neurological Outcome of Survived Patients.

Tables 5-7 shows comparison of patient, event and treatment variables by of survival to discharge. Total 8 (10%) of patients survived to discharge. 37.5% (n=3) of were from ED and 62.5 (n=5) from Inpatient group. Table 5 shows patient variables by survival to discharge, 87.5%(n=7) were male and 75% (n=6) of those survived to discharge were less than 1 years of age. 87.5% (n=7) of survived patients had pre-existing conditions. On of the patient variable were found to be statistically significant.

Citation: Ramachandran S, Lal N, Panchatcharam SM, et al. Pediatric cardiopulmonary resuscitation: comparison between emergency department and inpatients setting at a tertiary academic hospital in Oman. *J Anesth Crit Care Open Access.* 2021;13(4):155–164. DOI: 10.15406/jaccoa.2021.13.00488

Table 6 compares event variables by survival to discharge. 75% (n=6) of cases survived to discharge had respiratory cause as the immediate cause & 87.5% (n=7) were monitored prior to CPR. 75% (n=6) of survived patients had bradycardia with hypoperfusion. None of the event variables were found to be statistically significant. Table 7 compares treatment variables by survival to discharge. All patients 100% (n=8) who survived to discharge were those who had CPR less than 20 minutes. Regarding sodium bicarbonate use 62.5% (n=5) who survived to discharge did not receive it. The duration of CPR & not using sodium bicarbonate was found to be statistically significant factors for survival to discharge with p-value of 0.006 & 0.024 respectively.

Figure 4 shows comparison of outcome variables between the two settings. Although 19.2% (n=5) survived 24 hours in ED compared to 8.9% (n=5) in in-patient group, it was no statistically significant. Figure 5 shows neurological outcome of survived patients.

Table 1 Patient characteristics by admitting ward

Characteristics	Total n=83 (%)	EMD n=27 (%)	In-patient n=56 (%)	p-Value
Gender – Male	48 (57.8)	16 (59.3)	32 (57.1)	1.000
Age category				
0-3 months	19 (22.9)	9 (33.3)	10 (17.9)	
3-6 months	10 (12.0)	3 (11.1)	7 (12.5)	
6 months – 1 year	12 (14.4)	2 (7.4)	10 (17.9)	
1-4 years	17 (20.4)	5 (18.5)	12 (21.4)	0.549
4-10 years	16 (19.3)	6 (22.2)	10 (17.9)	
10-13 years	9 (10.9)	2 (7.4)	7 (12.5)	
Weight in Kgs (Median, Range)	8	7.12 (1.7-27)	9 (2.5-47)	0.416
Nationality - Omani	80 (96.4)	27 (100.0)	53 (94.6)	0.547
Pre-existing illness				
None	26 (31.3)	14 (53.8%)	12 (21.8%)	
Cardiac	6 (7.2)	3 (11.5%)	3 (5.5%)	
Respiratory	4 (4.8)	-	4 (7.3%)	0.006
Others	45 (54.2)	9 (34.6%)	36 (65.5%)	
On Chronic medications	51 (61.4)	11 (42.3%)	40 (71.4%)	0.015
Previous cardiac surgeries	2 (2.4)	1 (3.8%)	1 (3.8%)	0.538
Neurological impairment	50 (60.2)	6 (66.7)	44 (95.7)	0.027
Pre-event cardiovascular support	35 (42.1)	-	35 (63.6)	<0.001
Pre-event respiratory support	39 (46.9)	-	39 (70.9)	<0.001

Table 2 Comparison of event variables with site of CPR done

Event variables	Total n=83 (%)	EMD n=27 (%)	Inpatient n=56 (%)	p-Value
Immediate cause				
Cardiac	20 (24)	6 (24.0)	14 (25.0)	1.000
Respiratory	61 (73.5)	19 (76.0))	42 (75.0)	
Monitored / Witnessed	58 (69.8)	3 (11.1)	55 (98.2)	<0.001
Initial arrest				
Aystole	26 (31)	22 (81.5)	4 (7.1)	
PEA	1 (1.2)	-	1 (1.8)	
Shockable-vf/pvt	2 (2.4)	-	2 (3.6)	<0.001
Brady with hypoperfusion	54 (65)	5 (18.5)	49 (87.5)	

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Table Continued...

Event variables	Total n=83 (%)	EMD n=27 (%)	Inpatient n=56 (%)	p-Value
Subsequent shockable rhythm	6 (7.2)	1 (3.7)	5 (9.1)	0.658
Weekend	28 (33.7)	9 (33.3)	19 (33.9)	1.000
Time of working hours				
7-3pm	26 (31.3)	8 (29.6)	18 (32.7)	
3-11pm	36 (43.2)	14 (51.9)	22 (40.0)	0.548
11-7am	20 (24)	5 (18.5)	15 (27.3)	

Table 3 Comparison of treatment variables with site of CPR done

Treatment variables	Total n=83 (%)	EMD n=27 (%)	Inpatient n=56 (%)	p-Value
Duration of CPR <=20 mins	45 (54.2)	17 (63.0)	28 (50.0)	0.348
Defibrillation use	8 (9.6)	2 (7.4)	6 (10.7)	1.000
Invasive airway management	76 (91)	21 (84.0)	55 (98.2)	0.030
Line				
Intravenous	27 (32.5)	16 (59.3)	11 (20.0)	
Intra-arterial	1 (1.2)	1 (3.7)	-	<0.001
Intra-osseus	12 (14.4)	9 (33.3)	3 (5.5)	
CVC/Central line	42 (50.6)	1 (3.7)	41 (74.5)	
Sodium bicarbonate	61 (73.4)	17 (63.0)	44 (78.6)	0.184
Calcium gluconate	16 (19.2)	4 (14.8)	12 (21.4)	0.564
Amiodarone	4 (4.8)	-	4 (7.1)	0.299
Atropine	7 (8.4)	3 (11.1)	4 (7.1)	0.677
Sustained return of spontaneous circulation	12 (14.4)	6 (22.2)	6 (10.7)	0.191

Table 4 Treatment covariables by patient group

Covariate	EMD	PICU/Ward	p-Value
Number of defibrillation given (Median, Range)	3 (1-5)	2 (1-5)	1.000
Number of epinephrine doses given (Median, Range)	4 (1-10)	5 (0-14)	0.041
Time to first epinephrine dose in min (Median, Range)	4 (0-13)	0 (0-10)	<0.001
Duration of CPR in minutes (Median, Range)	17 (7-56)	20.5(3-54)	0.316

Table 5 Comparison of patients variables by survival to discharge

Characteristics	Survival to discharge No (n=75)	Yes (n=8)	p-Value
Gender			
Male	41 (55.4)	7 (87.5)	0.131
Female	33 (44.6)	1 (12.5)	
Age category			
Up to 1 year	34 (45.9)	6 (75.0)	0.150
≥ year	40 (54.1)	2 (25.0)	
Weight in Kgs (Mean Rank)	39.06	33.75	0.520
Nationality			
Omani	73 (98.6)	6 (75.0)	0.024
Non-omani	1 (1.4)	2 (25.0)	
Pre-existing illness			
None	24 (33.3)	1 (12.5)	0.287
Cardiac	6 (8.3)	-	
Respiratory	3 (4.2)	1 (12.5)	
Others	39 (54.2	6 (75.0)	
On Chronic medications			
Yes	45 (60.8)	6 (75.0)	0.704
No	29 (39.2)	2 (25.0)	
Previous cardiac surgeries			
Yes	2 (2.7)	-	1.000
No	72 (97.3)	8 (100.0)	

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Table Continued...

Characteristics	Survival to discharge No (n=75)	Yes (n=8)	p-Value
Neurological impairment			
Yes	43 (89.6)	7 (100.0)	1.000
No	5 (10.4)	-	
Pre-event cardiovascular support			
Yes	34 (47.2)	1 (12.5)	0.073
No	38 (52.8)	7 (87.5)	
Pre-event respiratory support			
Yes	37 (51.4)	2 (25.0)	0.265
No	35 (48.6)	6 (75.0)	
Site of arrest			
ED	23 (31.1)	3 (37.5)	0.704
PICU/Ward	51 (68.9)	5 (62.5)	

Table 6 Comparison of event variables with survival to discharge

Event variables	Survival to discharge No(n=75)	Yes (n=8)	p-Value
Immediate cause			
Cardiac	18 (25.0)	2 (25.0)	1.000
Respiratory	54 (75.0)	6 (75.0)	
Monitored / Witnessed			
Yes	50 (67.6)	7 (87.5)	0.424
No	24 (32.4)	1 (12.5)	
Initial arrest			
Aystole	24 (32.4)	1 (12.5)	0.310
PEA	1 (1.4)	-	
Shockable-vf/pvt	1 (1.4)	1 (12.5)	
Brady with hypoperfusion	48 (64.9)	6 (75.0)	
Subsequent shockable rhythm			
Yes	5 (6.8)	1 (12.5)	0.475
No	68 (93.2)	7 (87.5)	
Day			
Week days	50 (67.6)	4 (50.0)	0.435
Weekends	24 (32.4)	4 (50.0)	
Time of working hours			
7-3pm	24 (32.9)	2 (25.0)	0.250
3-11pm	33 (45.2)	2 (25.0)	
11-7am	16 (21.9)	4 (50.0)	

Table 7 Comparison of treatment variables with survival to discharge

Treatment variables	Survival to discharge No(n=75)	Yes (n=8)	p-Value
Duration of CPR			
≤ 20 mins	36 (48.6)	8 (100.0)	0.006
> 20 mins	38 (51.4)	-	
Defibrillation use			
Yes	7 (9.5)	1 (12.5)	0.577
No	67 (90.5)	7 (87.5)	
Invasive airway management			
Yes	67 (93.1)	8 (100.0)	1.000
No	5 (6.9)	-	
Line			
Intravenous	23 (31.5)	3 (37.5)	0.955
Intra-arterial	1 (1.4)	-	
Intra-osseus	11 (15.1)	1 (12.5)	
CVC/Central line	38 (52.1)	4 (50.0)	
Sodium bicarbonate			
Yes	58 (78.4)	3 (37.5)	0.024
No	16 (21.6)	5 (62.5)	
Calcium gluconate			
Yes	16 (21.6)	-	0.344
No	58 (78.4)	8 (100.0)	
Amiodarone			
Yes	3 (4.1)	1 (12.5)	0.342
No	71 (95.9)	7 (87.5)	
Atropine			
Yes	5 (6.8)	2 (25.0)	0.137
No	69 (93.2)	6 (75.0)	

Discussion

Pediatric cardiac arrest is not a common event and constitute only 0.2% of overall pediatric admissions in Sultan Qaboos University Hospital, which is less than other studies that reached up to 2% of total pediatric admission.[2,3] This has impacted the number of cases included in our study. This makes continuous training and practice important to maintain such uncommonly encountered resuscitation skills. In our study, we demonstrated that the overall outcome from pediatric CPR was not significantly different between ED & inpatients setting although there were some statistical significant differences in few variables.

In our study, 50% of patients were younger than 1 year with

58% being males which is almost similar to other published studies. A literature review of pediatric CPR published in 1999 with more than 3000 patients included in 44 different studies showed that 56% of cardiac arrest cases were younger than one year with 62% being males.[1] Respiratory arrest was the most common cause of arrest in 73.5% of the cases. This is slightly higher than other studies, but respiratory failure was still the most common cause of cardiac arrest in 60% of cases.[1] Pre-existing conditions were present in almost half of children in our study (66%) and were associated with increased discharge to survival (n=7).

In our study, among the survival to discharge patients, 75% (n=6) were less than 1 year of age. Studies have shown survival after pediatric in-hospital arrest considered to be age dependent. Age <1 year is associated with substantially better ROSC and survival to discharge. The American Heart Association (AHA) national registry CPR data indicated that outcome from in-hospital cardiac arrest is substantially better in infants than in older children, perhaps because of the superior perfusion during CPR & increased chest wall compliance.[14-16] Although in our study, males predominantly were associated with survival though studies showed gender, ethnicity, race were not associated with survival or neurobehavioral function.[27]

Bradycardia with hypo-perfusion was the common initial rhythm (65%) observed in our study followed by 31% asystole or pulseless electrical activity (PEA). Only 2.4% had ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT) which is less than previously reported studies for shockable rhythm . Asystole had worse outcome and VF/VT had better outcomes consistent with other research.[28] One study of 1420 cases reported that the initial rhythm in 73% of the cases was brady-asystole or PEA and 10% had VF/pVT. Although Studies showed that VF and pVT had better survival rate compared to asystole with 73% versus 5%[7]. In our study among patients survived to discharge, 6 had initial rhythm bradycardia with hypo-perfusion, 1 with VF/pVT and 1 with asystole as initial rhythm respectively. 81.5% of pediatric CPR in ED had asystole as initial rhythm and none with shockable rhythm (VF/pVT) while 87.5% of pediatric CPR in Inpatient setting had bradycardia with hypoperfusion as initial rhythm and 3.6% with shockable rhythm (VF/pVT). Majority of arrests occurred during weekdays 65.8%. 42.6% of pediatric arrests occurred during evening hours, 31.7% morning hours, 24% during night hours. There was no difference in survival to discharge in both weekdays and weekends. Though studies have shown rates of survival to hospital discharge was lower for pediatric CPR events occurring at night than for CPR events occurring during daytime and evening hours[29] however, 50% of patients who survived to discharge were those who had CPR event during night hours in our study. 89% of arrests arrives in ED were unmonitored and/or unwitnessed and on the other hand, 98% (n=55) cases were monitored and/or witnessed in the In-patient group. 87.5% (n=7) survived to discharged were those who had witnessed and/or monitored arrests (2 in ED and 5 in PICU). The literature supports that the patients who are monitored and/or witnessed at the time of cardiac arrest demonstrate a significantly higher survival rate to hospital discharge compared to those patients neither monitored nor witnessed. Cardiac monitoring confers no additional outcome benefit over direct observation of patients suffering in-hospital cardiac arrest.[30]

The duration of CPR also correlated with survival. All the 8 patients who survived to discharge were those who had CPR ≤ 20minutes in this study. In ED, 63% of cases had CPR duration less than 20 minutes and 50% in Inpatient settings. None of our patients who had CPR for more than 20 minutes survive to discharge. In ED, ROSC achieved in 22.2% of children who had CPR less than 20 minutes with 19.2% survived at 24 hours and 11.5% survived by one year while in Inpatient setting, ROSC achieved in 10.7% of children who had CPR less than 20 minutes with 8.9% survived at 24 hours and one year in our study. Other studies showed that ROSC achieved in 64% of children of CPR less than 20 minutes with 30% of them survived 24 hours but only 15 % survived by one year.[1]

In our study, there was more delay in first dose epinephrine administration in ED arrests compared to Inpatient settings with median time to first epinephrine dose in ED is four minutes compare to zero minutes for arrests in inpatient settings. This difference is due to absence of vascular access and the duration taken to establish vascular access (Intravenous/Intraosseous) in ED settings compared to the existence of vascular access either as Intravenous (IV) or central line in the Inpatient setting. Although studies have shown that delay in administration of epinephrine was associated with decreased chance of survival to hospital discharge, ROSC, 24-hour survival, and survival to hospital discharge with a favorable neurological outcome,[23] there was no significant difference in survival outcome between ED and inpatients setting in our study. Based on AHA recommendation rapid establishment of vascular access is more important site of access and need to be established within 30-60 seconds if you fail to get venous access.[24-26] Despite that we still believe that the IO is underutilized as an important resuscitation access and in our study only 12 patients received IO access out of which only 1 patient survived to discharge.

Frequency of epinephrine administration and duration of CPR were used as measures to determine outcome in several studies.[1,16] In 4 studies with 198 cardiac arrest cases, zero survivals to discharge found after the use of more than two epinephrine doses.[6] In our study, none survived to discharge for those who had more than 2 doses of epinephrine in Inpatient settings whereas 3 patients who survived to discharge in ED setting, used more than 2 doses of epinephrine. In some hospitals there are rapid response specialized teams which consist of doctors and nurses who aim to treat critically ill patients before cardiac or respiratory arrest occurs. These teams are variously termed medical emergency teams (MET), rapid response teams (RRT), or intensive care unit (ICU) outreach teams.[17] Unfortunately, in our hospital settings such teams exist only for adult care with no pediatric coverage unless cardiac arrest occurs.

Sodium bicarbonate was used in 73% of patients and 37.5% of them survived to discharge. Despite limited recommendations for using sodium bicarbonate during CPR, it is still used frequently during pediatric cardiac arrests in ICU, specially with prolonged CPR, hyperkalemia and acidemia; and as a result it is usually associated with poor prognosis.[21] Although, it may improve acid-base status, but it did not improve ROSC and good neurologic survival.[22] There was no statistical significance in survival to discharge with the use of other medications such as calcium gluconate, amiodarone & atropine. As per studies, although calcium used frequently during in-hospital pediatric CPR, it is associated with decreased survival to hospital discharge and unfavorable neurological outcome.[31] In our study only 2 patients had shockable arrest rhythms out of which one patient survived to discharge. There is no evidence that routine use of other drugs such as atropine increases survival to hospital discharge.[32]

Neurological status is considered as an outcome variable in pediatric arrest even though no uniform criteria were used.[8] Studies have shown that almost two thirds of in-hospital pediatric patients with cardiac arrest achieve ROSC, and approximately one-fourth survive to hospital discharge, of which almost three quarters had good neurologic outcome.[8-10] Neurological disability based on Pediatric Cerebral performance category scale was used for evaluating the

neurological outcome post-discharge.[8,9] Cerebral performance category reflected the quality of life after the event.[8] In this study, 89% of cases died. Both groups had remarkably high percentage of death, 87.5% in ED and 92.6% in in-patient setting respectively. Only 10% of patient in our study survived to discharge (n=8) with variable neurological outcomes (ranging from normal to severe disability) almost similar in both settings. Certain studies have shown better survival to discharge (25%).[9] Another study derived from Get with the guidelines- Resuscitation (GWTG- Resuscitation), formerly known as the National Registry Of Cardiopulmonary Resuscitation done from 2000-2009, also showed higher survival rate of 34% children with in-hospital cardiac arrest survived to hospital discharge with significant improvement in overall survival to discharge from 14% in 2000; to 43% in 2009.[11] However, this data could be an overestimate when compared to our study due to small sample size and difference in age-group inclusion criteria as most pediatric CPR studies are based on age group until 18 years of age while our study included only up to 12 years of age.

Limitation

There were many limitations in this study. Foremost this is a single-center study. Due to the retrospective nature of the study, having an extremely small sample size that could not provide enough statistical power to infer difference between ED and inpatients pediatric cardiac arrests. Another limitation was related to the data collection as most data was collected based on clinical notes in track care system & CPR sheets that did not describe much on the data on the monitoring quality of Cardiopulmonary Resuscitation techniques, PALS Provider renewal status of team members, blood gas report on pH, potassium, lactate documentation. There were few cases was found to have missing records. It was not possible to get data prior to 2012 due to absence of computerized data sheets of CPR. Another prominent limitation factor is the age criteria pediatric group for our study that was less than 13 years of age while studies used for references considered pediatrics with age below 18 years.

Implications of study

This study not only presented an insight on pediatric CPR held within a tertiary hospital setting and the survival outcomes but is also one of the first studies conducted on analyzing pediatric CPR held in Oman. Although this study have small sample size , it would pioneer for an elaborative work in a broader scale by forming multi-center data analysis from all pediatric resuscitations held within hospitals in Oman that would help to assess strengths & drawbacks in managing cardiopulmonary resuscitation and thereby work to improve for better survival outcomes in pediatric cardiac arrests.

Conclusion

The survival outcome in resuscitation was almost similar between ED & In-patient setting (PICU/wards) cardiopulmonary arrests despite having few significant differences based on variables. Overall, 10% of patients survived to discharge and higher survival rates are associated with duration of CPR less than 20 minutes. Intraosseous route is underutilized and should be applied earlier especially in ED to prevent delay in administration of resuscitation medications.

Author disclosure of relevant financial relationships/conflict of interest

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