RESEARCH ARTICLE

Factors affecting survival and neurological outcomes for patients who underwent cardiopulmonary resuscitation

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Abstract

Objective: To determine the impact of arrest location, arrest reason, the return of spontaneous circulation positivity, duration of cardiopulmonary resuscitation, chest compression method, and cardiac rhythm at the time of hospital admission on survival rates and neurological outcome in cardiac arrest cases.

Methods: The retrospective study was conducted at Bolu Abant Izzet Baysal Training and Research Hospital, Turkey, and comprised data related to the period from January 1, 2016, to June 31, 2018, of patients who received cardiopulmonary resuscitation at the Emergency Department. Demographic characteristics of the patients, the return of spontaneous circulation, and 6-month survival rates were evaluated with the use of a modified Rankin scale. Data was analysed using SPSS 25.

Findings: Of the 177 cases, 109(61.58%) were male. The return of spontaneous circulation was noted in 72(40.68%) patients. In-hospital, cardiac arrest developed in 80(45.20%) patients, and chest compression wasperformed on 105(59.32%) with the use of a mechanical chest compression device. A non-shockable rhythm state was observed in 150(84.75%) patients, and 18(10.17%) survived at the end of the sixth month.

Conclusion: The return of spontaneous circulation rate was higher and the neurological prognosis was more positive in patients on whom cardiopulmonary resuscitation was performed for a shorter time period and who had a shockable cardiac rhythm at the time of admission.

Keywords: Cardiopulmonary resuscitation, Mechanical chest compression device, Neurological outcome.
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Introduction

Cardiac arrest (CA) is a state where the heart functions stop unexpectedly, and the pulse is not palpable cannot be taken, resulting in a loss of breathing and consciousness.[1] Cardiopulmonary resuscitation (CPR) defines the implementation of all actions necessary for increasing the chance of survival subsequent to CA.[2] Closed chest compression was suggested as the treatment of the above-mentioned condition in 1960, and since then many developments and improvements have been made in advanced cardiac life support in the last 60 years. However, despite all these developments, deaths induced by sudden CA continues to be a problem.[3]

Worldwide, more than 55.3 million people present to the Emergency Department (ED) due to CA during a 1-year period. In the united States of America, 300,000 patients are admitted to the EDs for CA in 1 year; similarly, in Europe, around 275,000 CA cases have been recorded. When arrest aetiology is examined, nearly 70% of the cases are of cardiac origin. Of these, 8-10% of the out-of-hospital CA (OHCA) cases can be discharged, while this rate reaches nearly 22-28% in in-hospital CA (IHCA) cases. Of the cases that are discharged, about 65% suffer from neuro-psychiatric problems and 35% of the cases have irreversible cognitive inefficiency.[4]

Existing resuscitation guides emphasise the importance of high-quality CPR to get the best results in CA cases. High-quality CPR is defined as attaining adequate depth in chest compression (5-6 cm), having a compression rate of around 100-120 per minute, minimising the number of interruptions and allowing the chest to bound back between chest compressions during CPR.[5] Interruptions during CPR are harmful. The most critical time to minimise interruptions during CPR is the time when defibrillation is tried. Long periods of preliminary shock and peri-shock interruptions at CPR reduce the success of the shocks and the survival chance.[6] The key element of survival during CPR is the implementation of an efficient chest

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compression. However, mechanical chest compression devices (MCCDs) were developed due to the fatigue in medical staff and the need for extra personnel, especially during long-lasting resuscitation processes.[7]

There is a limited number of studies carried out on the prognosis before and after CPR in Turkey. Moreover, no research has been recorded in literature regarding the use of MCCDs during CPR in the country. The current study was planned to search for aetiological, demographic, and clinical characteristics of CA cases to determine the factors influencing the prognosis of the patients.

Patients and Methods

The retrospective study was conducted at Bolu Abant Izzet Baysal Training and Research Hospital, Turkey, and comprised data related to the period from January 1, 2016, to June 31, 2018, of patients who received CPR in ED, After approval from the institutional ethics board, data was collected related to patients aged 18 years or older who were either brought due to CA or developed CA while the examination-treatment period was ongoing. The survival data within a 6-month period was obtained from epicrisis records located in the hospital automation system until December 31, 2018. Demographic data and clinical findings of the patients were taken from the hospital automation system. The data of the patients discharged or transferred to another hospital in the 6-month period were obtained from the patients or their relatives through personal communications with the phone numbers registered in the automation system.

Using a standard data collection form, age, gender, accompanying chronic illnesses, arrest location and arrest aetiology of the patients, CPR duration, implementation type of the chest compression (by hand or MCCD) during resuscitation, and cardiac rhythm data at the time of admission to the hospital were recorded. Patients with missing or no information were excluded, and so were those aged <18 years, being pregnant or breastfeeding.The primary endpoint of the study was the return of spontaneous circulation (ROSC). The second endpoint was the 6-month survival data. Modified Rankin scale (MRS) was used in order to evaluate the neurological endpoint after resuscitation.[8] Zero to one point was assigned to patients who were defined as having a mild disability, two to three points were given to patients who were defined as having a moderate disability, and four to five points were assigned to those defined as having heavy disability. Data of all patients was compared between these two endpoints.

Statistical analysis of the data was done using SPSS 25. Variables were summarised using mean ± standard deviation (SD), median (minimum-maximum), and frequency and percentages, as appropriate. The normality of continuous variables was assessed using Shapiro-Wilk tests; for the group comparisons, independent samples t-tests and one-way analysis of variance (ANOVA) were used for continuous variables. Categorical variables were analysed with Chi-square tests with Fisher's exact correction where required. In addition to the univariate analysis, multivariate survival analysis was conducted for the 6-month survival data of the patients in which ROSC was obtained. For the survival analysis, Cox proportional hazard regression model was used and hazard ratios (HRs) for the risk factors were calculated, after adjusting for age, gender and other independent variables. Significance was set at $p<0.05$.

Results

Of the 177 patients, 109(61.58%) were male and 68(38.42%) were female. Overall, 105(59.32%) patients lost their lives, and ROSC was ensured in 72(40.68%) (Table 1). Age and gender were not significantly different between the groups ($p>0.05$). OHCA was the case with 97(54.8%) patients, while 80 (45.2%) developed IHCA. Overall, 110(62.15%) patients suffered from hypertension (HT), 51(28.81%) had diabetes mellitus (DM), 59(33.3%) had coronary artery disease (CAD), 25(14.12%) had cerebrovascular accident (CVA), 32(18.07%) had cancer, and 7(3.95%) had chronic renal failure (CRF). Chest compression was performed on 72(40.68%) patients through manual method while MCCD was used for 105(59.32%). Rhythm analysis of 150(84.75%) patients was non-shockable and 27(15.25%) had a shockable rhythm at the time of admission. Cardiac-induced arrest was developed in 57(32.2%) patients and trauma-induced arrest was developed in 25(14.12%). Resuscitation took <10 minutes in 20(11.3%) patients, 10-30 minutes in 55(31.07%) and it >30 minutes in 102(57.63%) patients.

Of the total, 18(10.17%) patients survived at the end of the sixth month while 159(89.83%) had lost their lives. The average age of the surviving patients was 53.17±16.42 years, and that of the ones losing their lives was 66.95±16.22 years. Manual method of chest compression was used on 13(72.2%) of the surviving patients and MCCD

Table-1: Comparison of variables for ROSC and mortality.

	ROSC (n=72)	Exitus (n=105)	*p*-value
Age (mean ± SD)	62.85 ± 16.64	67.40 ± 16.61	0.07
Gender			0.25
Male	48/72 (66.7%)	61/105 (58.1%)	
Female	24/72 (33.3%)	44/105 (41.9%)	
Arrest location			0.17
OHCA	35/72 (48.6%)	62/105 (59.0%)	
IHCA	37/72 (51.4%)	43/105 (41.0%)	
Additional illnesses			0.38
HT	42/72 (58.3%)	68/105 (64.8%)	
DM	23/72 (31.9%)	28/105 (26.7%)	0.44
CAD	26/72 (36.1%)	33/105 (31.4%)	0.51
CVA	7/72 (9.7%)	18/105 (17.1%)	0.16
CA	12/72 (16.7%)	20/105 (19.0%)	0.68
CRF	3/72 (4.2%)	4/105 (3.8%)	0.90
Chest compression type			0.07
By hand	35/72 (48.6%)	37/105 (35.2%)	
MCCD	37/72 (51.4%)	68/105 (64.8%)	
Cardiac rhythm			<0.001
Non-shockable	50/72 (69.4%)	100/105 (95.2%)	
Shockable	22/72 (30.6%)	5/105 (4.8%)	
Arrest reason			
Cardiac	39/72 (54.2%)	18 /105 (17.1%)	<0.001
Trauma	6/72 (8.3%)	19 /105 (18.1%)	0.06
CPR time period			<0.001
<10 minutes	19/72 (26.4%)	1 /105 (1.0%)	
10-30 minutes	42/72 (58.3%)	13/105 (12.4%)	
>30 minutes	11/72 (15.3%)	91/105 (86.7%)	

Categorical data summarized as frequency (%) and analyzed with chi-square tests. Normally distributed data summarized as mean ± SD and analyzed with independent samples t-tests. n: number of patients, sd: standard deviation, ROSC: Return of Spontaneous Circulation, OHCA: Out-of-Hospital Cardiac Arrest, IHCA: In-Hospital Cardiac Arrest, HT: Hypertension, DM: Diabetes Mellitus, CAD: Coronary Artery Disease, CVA: Cerebrovascular Accident, CA: Cancer, CRF: Chronic Renal Failure, MCDD: Mechanical Chest Compression Device, CPR: Cardiopulmonary Resuscitation.

Table-2: Comparison of variables for 6-month survival and exitus groups.

Variables	Survival (n=18)	Exitus (n=159)	*p*-value
Age (mean ± SD)	53.17 ± 16.42	66.95 ± 16.22	0.001
Gender			0.64
Male	12/18 (66.7%)	97/159 (61.0%)	
Female	6/18 (33.3%)	62/159 (39.0%)	
Arrest location			0.05
OHCA	9/18 (50.0%)	88/159 (55.3%)	
IHCA	9/18 (50.0%)	71/159 (44.7%)	
Additional illnesses			
HT	12/18 (66.7%)	98/159 (61.6%)	0.67
DM	5/18 (27.8%)	46/159 (28.9%)	0.91
CAD	4/18 (22.2%)	55/159 (34.6%)	0.22
CVA	1/18 (5.6%)	24/159 (15.1%)	0.27
CA	1/18 (5.6%)	31/159 (19.5%)	0.14
CRF	0/18 (0%)	7/159 (4.4%)	0.36
Chest compression type			0.004
By hand	13/18 (72.2%)	59/159 (37.1%)	
MCCD	5/18 (27.8%)	100/159 (62.9%)	
Cardiac rhythm			<0.001
Non-shockable	9/18 (50.0%)	141/159 (88.7%)	
Shockable	9/18 (50.0%)	18/159 (11.3%)	
Arrest reason			
Cardiac	14/18 (77.8%)	43/159 (27.0%)	<0.001
Trauma	2/18 (11.1%)	23/159 (14.5%)	0.69
CPR time period			<0.001
<10 minutes	10/18 (55.6%)	10/159 (6.3%)	
10-30 minutes	6/18 (33.3%)	49/159 (30.8%)	
>30 minutes	2/18 (11.1%)	100/159 (62.9%)	

Categorical data summarized as frequency (%) and analyzed with chi-square tests. Normally distributed data summarized as mean ± SD and analyzed with independent samples t-tests. n: number of patients, sd: standard deviation, ROSC: Return of Spontaneous Circulation, OHCA: Out-of-Hospital Cardiac Arrest, IHCA: In-Hospital Cardiac Arrest, HT: Hypertension, DM: Diabetes Mellitus, CAD: Coronary Artery Disease, CVA: Cerebrovascular Accident, CA: Cancer, CRF: Chronic Renal Failure, MCDD: Mechanical Chest Compression Device, CPR: Cardiopulmonary Resuscitation.

was used on 5(27.8%) patients who survived. Of the survivors, 14(77.8%) patients had cardiac-induced arrest, 2(11.1%) had trauma-induced arrest, 9(50%) had a shockable rhythm at the time of admission, CPR duration of 10(55.6%) was <10 minutes, and CPR duration of 2(11.1%) was >30 minutes (Table 2).

Patients' age and CPR duration were significant predictors of longer survival after controlling for other factors (p<0.05). One year increase in age increased the hazard of death by 1.034 times (p=0.003). When CPR time was 10-30 minutes, hazard of death was 2.5 more than the patients with CPR time <10 minutes (p=0.045) and when the CPR time was >30 minutes, the hazard of death was 3.6 times more than the patients with CPR time <10 minutes (p=0.022) (Table 3). Survival probability of the patients according to CPR duration was also plotted (Figure).

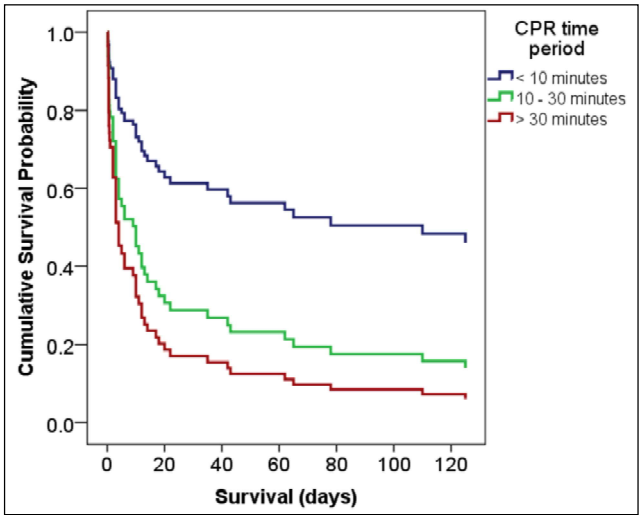

Figure: Survival probability of the patients according to the Cardiopulmonary Resuscitation (CPR) time period.

Table-3: Results of the Cox regression model for survival analysis.

Factors	β	HR	%95 CI of HR	*p*-value
Age	0.033	1.034	(1.011, 1.057)	0.003
Gender, *male*	-0.211	0.809	(0.436, 1.501)	0.502
Arrest location, *IHCA*	0.253	1.287	(0.700, 2.367)	0.417
Chest compression type, *MCCD*	-0.026	0.974	(0.483, 1.964)	0.941
Cardiac rhythm, *shockable*	-0.506	0.603	(0.273, 1.33)	0.210
Cardiac	-0.622	0.537	(0.279, 1.031)	0.062
Trauma	-0.420	0.657	(0.188, 2.299)	0.511
CPR time period				
<10 minutes	reference			
10-30 minutes	0.935	2.548	(1.020, 6.367)	0.045
>30 minutes	1.287	3.622	(1.201, 10.926)	0.022

HR: Hazard Ratio; CI: Confidence Interval. IHCA: In-Hospital Cardiac Arrest, MCCD: Mechanical Chest Compression Device, CPR: Cardiopulmonary Resuscitation.

Discussion

The main objective of CPR is to ensure ROSC and to discharge the patients with the least possible neurological damage. All over the world, many studies have been carried out and are continuing to be performed in order to estimate the prognosis of this patient group. Literature suggests that the chance of CA in the male population is higher. Moreover, the rates of ROSC and discharge gradually decrease together with increasing age.[9-11] While the survival rate of IHCA patients generally range 15-20%, this rate was determined to be 13-37% in one study.[12,13] In another study, the discharge rate of OHCA patients was 10.7%.[14] In our study, the number of male patients was higher and ROSC and survival rates decreased with increasing age which is similar to the literature.[9,10,12] Although there is a numerical difference between IHCA and OHCA patients in terms of ROSC and 6-month survival rates, no statistically significant difference was found. We believe that this outcome results from an insufficient number of patients.

MCCDs are devices designed to maintain uninterrupted chest compressions during CPR in CA patients. Numerous clinical and experimental studies have been carried out on these devices in the last 15 years. MCCD and manual chest compressions were compared in an experimental study.[15] It was observed that the patients treated with MCCD had higher pressure of coronary perfusion, cerebral blood flow, and higher rate of ROSC. Hallstrom et al. reported in their compilation discussing 10 studies that the rate of survival and neurological outcomes were found to be more negative if resuscitations were made with the use of MCCDs.[16] American Heart Association (AHA) guidelines indicate that manually-implemented chest compressions are the standard CA treatment, and it does not suggest the routine use of MCCD. However, the guideline states that MCCDs can be used in specific circumstances where the application of chest compression becomes difficult and dangerous for the medical personnel on the condition that the use of the device does not interrupt the CPR.[17] In our study, manual and device-based CPR methods were compared and no difference was found in terms of ROSC. However, when evaluating the 6-month survival rate, it was determined that the survival rate was higher for the patients for whom the manual chest compressions were applied (p=0.004). As such, we concluded that MCCDs should not be used unless the situation cannot be avoided and due to the high probability of MCDD-related interruptions in CPR process in EDs.

Studies have demonstrated that ROSC rate is low if the rhythm of CA patients is non-shockable at the time of first admission (asystolia, pulseless electrical activity).[18] If a shockable rhythm is present at the time of admission (ventricular fibrilation, ventricular tachycardia), ROSC and survival rates are much higher in this particular patient group.[19] The cardiac rhythm of patients at the time of admission was examined in our study, and it was found that patients with a shockable rhythm had higher rates of ROSC and survival (p<0.001). Also, it was determined that the patients with shockable rhythm were discharged from hospital with a much better neurological state at the end of the 6-month (p =0.038). These findings are compatible with literature, and it should be remembered that arrest patients with shockable rhythm at the time of admission have a better neurological prognosis.[18]

In the literature, it has been determined that CA in aetiology has much higher rates of ROSC and survival compared to non-cardiac arrests.[20] A study on 98 patients found that CA aetiology of 52 patients was based on cardiac causes and reported that 16 of these patients (30.8%) survived after the treatment.[21] In our study, cardiac causes were identified in the aetiology of 39 patients (54.2%) out of the 72 patients with ROSC (p<0.001). Cardiac causes were also present in the aetiology of 14 patients (77.8%). Out of 18 surviving patients at the end of the 6th month (p<0.001). Our study was found to be compatible with literature.[20]

Studies have stated that there is a significant relationship between ROSC and survival, and the duration and the quality of the CPR process.[22-24] One study found that ROSC

and neurological values were significantly higher in the patients having a resuscitation <20 minutes when compared to the group that had >20 minutes.[25] In another study on 106 patients, significant ROSC rates were recorded in the patients with a CPR period <10 minutes.[26] In line with these studies, the current study found a negative correlation between CPR time period, ROSC and positive neurological prognosis.

Conclusion

Patients having a short CPR period and those with a shockable rhythm at the time of admission had higher rates of ROSC and much more positive neurological prognosis. Besides, patients receiving CPR through manual method gave more positive neurological responses, indicating that that MCCDs should be used only as a last resort.

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