Investigation of the efficacy of an advanced life support team and architectural design on the success of cardiopulmonary resuscitation in the department of emergency medicine

Sedat Bilge [1], Mehmet Eryılmaz [1], Ali Attila Aydın [2]

(1) University of Health Sciences, Gulhane Training and Research Hospital, Department of Emergency Medicine, Ankara, Turkey

(2) Miaclinics, Healthy Life Clinic, Istanbul, Turkey

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Corresponding Author:
Sedat Bilge
University of Health Sciences, Gulhane Training and Research Hospital, Department of Emergency Medicine, Ankara, Turkey
sedatotuz@gmail.com

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ABSTRACT

Aims: This study aimed at comparing the success rates of cardiopulmonary resuscitation (CPR) between two different architecturally designed emergency departments (EDs) in the same facility.

Methods: This was a retrospective study conducted at an ED at a tertiary hospital. Subjects who underwent CPR due to cardiac arrest (CA) were included in two different ED types, a corridor-type ED (CED) and arena-type ED (AED). The CPR duration (minutes), return of spontaneous circulation (ROSC) rate, admission type and initial rhythm type were recorded. A positive ROSC was considered successful CPR. The results of the two ED types were compared.

Results: Overall, 380 CPR events were studied (mean age: 65.1 ± 15.5 years, male: 71%, n = 230 for the CED group; mean age: 64.8 ± 16.1 years, male: 63%, n = 150 for the AED group). The demographic characteristics of the two groups did not show a significant difference. The average durations of CPR were similar in CED and AED (36.1 ± 12.6 and 36.8 ± 15.1, respectively, p = 0.436). The rate of ROSC was higher in the AED group compared with the CED group (16.7% vs 9.6%, respectively, p = 0.01). There was no significant difference by the means of admission type or type of initial rhythm between the two groups.

Conclusions: This study showed that CEDs may be associated with lower CPR success rates than AEDs are. This may be the result of the composition of the team and available equipment, as well as the ED's architectural design.

Introduction

Despite technological advances aimed at preventing cardiac arrest (CA), it is still one of the leading causes of death worldwide, and an earlier return of spontaneous circulation (ROSC) in cardiopulmonary resuscitation (CPR) is essential for better outcomes (1-4). Beyond ROSC, successful CPR also indicates the restoration of quality of life and the functional health status of the individual to the baseline status from before CA (5). Teamwork, closed-loop communication, the responsibilities of the team leader, the provision of the minimum equipment for CPR and the nontechnical aspects of CPR training all have a significant effect on the success of CPR, and they have emerged as a separate area of research in recent years (1, 6). Resuscitation teams and equipment, as well as the architectural design of the emergency department (ED), all have a direct effect on the CPR success rate, and these factors must be fully considered if CPR interventions are to be standardised and efficient. To the best of our knowledge, this is the first study evaluating the influence of the team and the architectural design of the ED on the success rate of CPR in a restructured ED of the same facility.

Methods

This retrospective study was carried out in the Department of Emergency Medicine of the Gulhane Military Medicine Academy (GATA) between 1 June 2013 and 31 March 2014. The previous ED setup was the corridor-type ED (CED), but the department was transferred to a new building featuring an arena-type ED (AED) on 30 November 2008.

In the former CED layout, outpatients were evaluated in examination and treatment rooms located side by side along a corridor parallel to each other. The rooms were connected to the resuscitation room by a separate passage that ran between the rooms, parallel to the corridor (Figure 1). There was no specifically designed triage unit. The team members were composed of a physician pool including internal medicine and surgery attendings employed in the hospital and emergency physicians who worked in shifts in the ED. The CED system was developed for previous ED needs with a limited triage system, and patients were ordered with row numbers. Healthcare staff were unable to monitor all the patients because the rooms were located along a corridor and separated by walls.

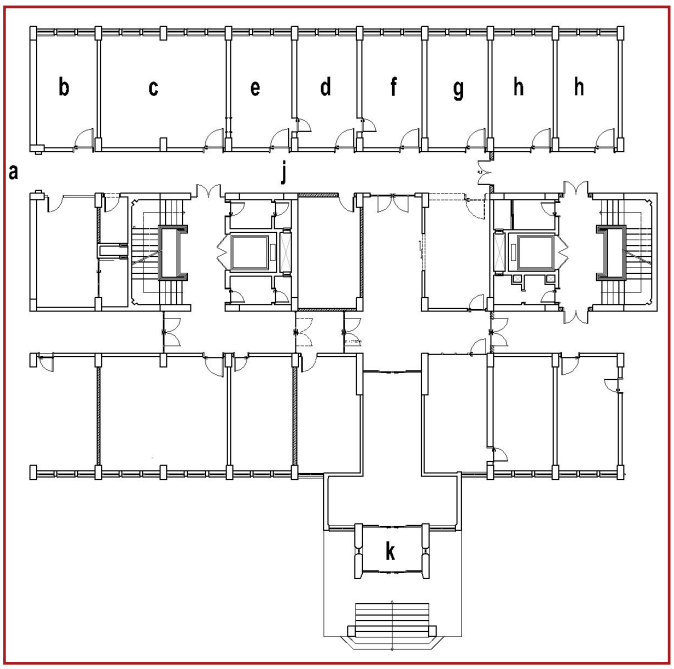

Figure 1. Corridor-type emergency department (CED): (a); patient entry area by ambulance, (b); paediatric emergency examination room, (c); surgical procedure and resuscitation room, (d); internal medicine emergency patient examination room, (e); surgical emergency examination room, (f); orthopaedics emergency examination room, (g); emergency biochemistry laboratory, (h); radiology, (j); patient waiting area and (k); outpatient admission area.

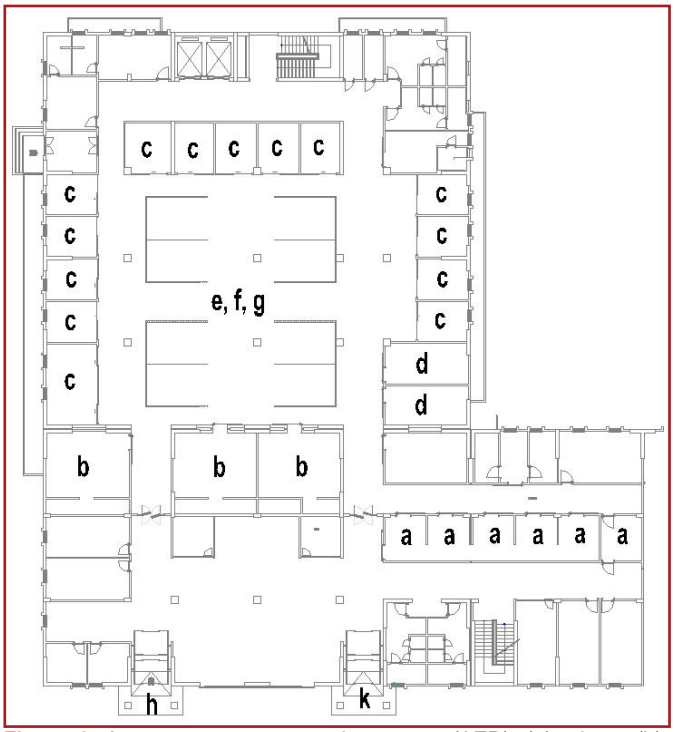

Figure 2. Arena-type emergency department (AED): (a); triage, (b); trauma and resuscitation rooms, (c); patient observation rooms, (d); radiology, (e); emergency medicine assistants and specialists, (f); emergency medicine nurses, (g); emergency department patient care staff, (h); patient entry area by ambulance and (k); outpatient admission area.

The AED layout was planned with a central working area where physicians, nurses and other healthcare personnel have specific workstations. Circling this area are examination and treatment cubicles, separated by thin walls and isolated by glass doors and curtains, that permit the attending healthcare personnel to see all the patients. These cubicles are used for observation and as resuscitation rooms, fully equipped for cardiac and trauma life support with appointed healthcare staff (Figure 2). The Triage section is accommodated as a separate unit with specific cubicles. In the AED layout, no attendings other than those providing emergency medicine are in the shift rota. The nurses and paramedics are selected from only the ED staff.

The CED group patients were selected retrospectively from between 30 November 2005 and 29 November 2008, and the AED group patients were selected from between 30 November 2008 and 30 November 2011. The data were obtained primarily from the hospital information system, while missing data were sourced from the inpatient hospital charts and hospital archives. All the cases that underwent CPR in the ED due to CA were included. Beyond the demographic data of each patient (age, gender), the duration of the CPR effort (minutes), ROSC status, admission type and initial rhythm in the ED were all recorded. In the assessment of the CPR success rate, CPR was considered positive for cases in which ROSC was achieved and lasted longer than 20 minutes. The patients were classified according to the following admission types: (a) cases brought to the ED via a 112 emergency medical system (EMS) ambulance, (b) cases arriving by any vehicle other than a 112 EMS ambulance and (c) cases suffering CA while under observation in the ED. The exclusion criteria were cases with insufficient data, patients under 18 years of age and trauma cases.

Statistical Analyses

SPSS for Windows Version 15.0 software was used for the statistical analyses. The normality of the distribution of the continuous variables was evaluated using a Kolmogorov–Smirnov test. The frequency, percentage, median (min–max) and mean ± standard deviation (SD) values were used for the descriptive statistics. A Chi-square test and Mann–Whitney U test were used for the comparison of discrete and continuous variables, respectively. A p-value < 0.05 was considered statistically significant.

Results

A total of 380 CPR (n = 150 for the AED group, n = 230 for the CED group) cases were included in the study. There was no statistically significant difference between the groups in terms of age or gender (p = 0.82 and 0.09, respectively). The demographic and descriptive data are given in Table 1.

The average duration of CPR was 36.16 ± 12.68 (min: 5, max: 90) minutes. No statistically significant difference was found in the average duration of CPR of the AED (36.8 ± 15.1 minutes) and CED (36.1 ± 12.6 minutes; p = 0.54; Table 1).

In the analysis of the 380 cases, 12.4% (n = 47) were positive and 87.6% (n = 333) were negative in terms of ROSC. For the CED and AED types, the success rates of CPR with positive ROSC were 9.6% (n = 22) and 16.7% (n = 25), respectively. This difference was found to be statistically significant (p = 0.04; Table 1).

The rates of different admission types were 55.5% (n = 211) for 112 EMS ambulances and 10% (n = 38) for vehicles other than 112 EMS ambulances. A total of 131 (34.5%) patients suffered CA during observation in the ED. No significant difference was identified between the two types of EDs in terms of

admission type (p = 0.57; Table 1). Furthermore, no statistically significant difference was identified between the two types of EDs in the initial rhythms (p = 0.43; Table 1).

For the patients admitted by 112 EMS ambulance, ROSC was positive in 8.1% (10/123) of cases in the CED group and 12.5% (11/88) in the AED group. This difference was not statistically significant (p = 0.29). In those admitted by any vehicle other than a 112 EMS ambulance, ROSC was positive in 16% (4/25) of the patients in the CED group and 7.7% (1/13) in the AED group. This difference was not statistically significant (p = 0.47). In the patients that suffered CA during observation in the ED, ROSC was positive in 9.8% (8/82) of the patients in the CED group and 26.5% (13/49) of the patients in the AED group (p = 0.01; Table 1). The difference in the initial rhythms of the ROSC cases was found to be statistically significant in the CED group but not the AED group (p = 0.01, p = 0.44, respectively; Table 2).

Discussion

Advanced cardiac life support (ACLS) and CPR target such optimal outcomes as long-term survival and no neurological sequelae, as well as the achievement of ROSC (1, 4). For this reason, the best care must be provided, for example, in terms of team composition and the architectural design of the ED (7). From the gathered data, it was ascertained that the patients' demographics and initial rhythms did not differ between the AED and CED layouts and the ROSC rates were higher for patients suffering from CA in the AED layout.

In the AED layout, the physicians and nurses are stationed at the centre of the area, and they can maintain control of the patient cubicles located around the periphery of this central area. The cubicles have transparent glass doors, allowing all the patients to be observed. Clearly, more focussed care can be provided to patients in an AED layout (8, 9). These factors may contribute to the increase in the CPR success rates.

In an ED-based study, Kozacı et al. (10) reported that the mean age was 61 ± 19 years in males and 67 ± 14 years in females, and the proportion of males in the sample was higher (65.2%). These findings are similar to those in the present study. Although our study was conducted in a military hospital, our study population was compatible with the populations in the literature, thereby increasing the significance and generalisability of the findings.

Table 1. Demographic and Clinic Admission Characteristics.

	CED n = 230 (60.5%)	AED n = 150 (39.5%)	p
Gender distribution			
Male	163 (70.9%)	94 (62.7%)	0.09*
Female	67 (29.1%)	56 (37.3%)	
Age (year), (mean ± SD)	65.1 ± 15.5	64.8 ± 16.1	0.82#
Duration of CPR (minute), (mean ± SD)	36.1 ± 12.6	36.8 ± 15.1	0.54#
Success rate of CPR			
ROSC	22 (9.6%)	25 (16.7%)	0.04*
Death	208 (90.4%)	125 (83.3%)	
Admission type			
By 112 EMS Ambulance	123 (53.5%)	88 (58.6%)	0.57*
By any other vehicle	25 (10.9%)	13 (8.7%)	
During observation in ED	82 (35.6%)	49 (32.7%)	
Initial rhythm seen in ED			
Asystole	190 (82.6%)	126 (84%)	0.43*
PEA	7 (3%)	7 (4.7%)	
PVT	1 (0.4%)	2 (1.3%)	
VF	32 (13.9%)	15 (10%)	
ROSC status by admission type			
By 112 EMS ambulance			
ROSC	10 (8.1%)	11 (12.5%)	0.29*
Death	113 (91.9%)	77 (87.5%)	
By any other vehicle			
ROSC	4 (16%)	1 (7.7%)	0.47*
Death	21 (84%)	12 (92.3%)	
During observation in ED			
ROSC	8 (9.8%)	13 (26.5%)	0.01*
Death	74 (90.2%)	36 (73.5%)	

*Chi-square test #Mann–Whitney U test, CED: Corridor-type emergency department, AED: Arena-type emergency department, SD: Standard deviation, CPR: Cardiopulmonary resuscitation, ROSC: Return of spontaneous circulation, EMS: Emergency medicine services, ED: Emergency department, PEA: Pulseless electrical activity, PVT: Pulseless ventricular tachycardia, VF: Ventricular fibrillation.

Table 2. Return of Spontaneous Circulation Status of the Cases Undergoing Cardiopulmonary Resuscitation According to Initial Type of Rhythm in Both Types of Emergency Department

	Death n (%)	ROSC n (%)	p*
ROSC status by the initial rhythm			
CED			0.01
Asystole	173 (91.1%)	17 (8.9%)	
PEA	7 (100%)	0 (0%)	
PVT	0 (0%)	1 (100%)	
VF	28 (87.5%)	4 (12.5%)	
AED			0.44
Asystole	107 (84.9%)	19 (15.1%)	
PEA	5 (71.4%)	2 (28.6%)	
PVT	1 (50%)	1 (50%)	
VF	12 (80%)	3 (20%)	

*Chi-square test, ROSC: Return of spontaneous circulation, CED: Corridor-type emergency department, AED: Arena-type emergency department, PEA: Pulseless electrical activity, PVT: Pulseless ventricular Tachycardia, VF: Ventricular fibrillation.

No specific time limit is set for the duration of CPR attempts in the ACLS guidelines. Bailey et al. (11) suggested that CPR can be ceased in patients who do not respond to ACLS for at least 20 minutes, although in the present study, the mean duration of CPR was greater than this.

Sittichanbuncha et al. (12) retrospectively analysed the outcomes of 181 patients who underwent CPR, and they reported a higher survival rate for in-hospital than out-of-hospital CAs, with ROSC rates longer than 20 minutes making up 59.1% of the cases. In a retrospective study by Amnuaypattanapon et al. (4), the researchers evaluated the resuscitation outcomes of cases (n = 138) with ROSC that continued for at least 20 minutes after successful CPR. The cases were divided into the three following groups: (a) those with sustained ROSC, (b) those that survived until discharge and (b) those that survived for 1 month after discharge. The results were reported as 22.5%, 5.6% and 3.6%, respectively. The authors identified the factors influencing ROSC success in the study noted above as the role of the resuscitation team, place of arrest, cause of arrest, presence of a shockable rhythm, time between CA and the start of chest compressions and duration of CPR. In comparison with this study, it was found that the ROSC results in the CED and AED were lower in the CED, but they were similar in the AED, with a higher rate of ROSC. This can be attributed to the fact that the ED design was optimised according to the current ED requirements, allowing a better guideline adaptation in the AED group. In addition, the data in the present study suggest that the architectural design of the ED made no difference in the duration of CPR efforts.

Effective CPR protocols can be managed when an immediate diagnosis of CA and effective CPR can be made and the team members act in harmony in all stages of the resuscitation. The development of concepts dictating the team makeup, team leadership and education of the team and leader is known to improve the outcomes of in-hospital CA cases (6, 7, 13, 14). In a study by Mellick et al. (6) in which the organisation of the resuscitation team was discussed, a team composed of experienced nurses and physicians educated in resuscitation was reported to reduce the number of mistakes during resuscitation. Efforts to establish Blue Code applications for in-hospital cases of arrest around the world are one of the most important indicators of such a need (15-17). GATA served as a Role 4 military hospital with a CED-style ED until 2008 in the same area. On 30 November 2008, the CED layout was abandoned and the AED layout adopted at a new facility. In the CED layout, the resuscitation team was composed of residents and attendings from different clinics rather than the ED, and their adaptation to the current CPR guidelines, as well as their communication skills with other staff, were limited. However, in the newly adopted AED layout, the team was composed of emergency residents and attendings supported by emergency nurses. The team members attended CPR training regularly, and they all had clearly identified roles, with their positions marked on the floor of the resuscitation room, defining the optimum location of the team leader, airway and circulation staff members. In addition, the CPR equipment was standardised for all resuscitation and observation units. It was concluded in the present study that the change of ED style and medical staff composition increased the CPR success rates.

Kozacı et al. (10) reported that 31.7% (n = 92) of patients (n = 290) undergoing CPR were transferred via 112 EMS ambulance or any vehicle other than a 112 EMS ambulance, while 68.3% (n = 198) sustained CA during follow up in the ED, and they reported higher success rates in patients who underwent CPR while being followed up in the ED. In the present study, among the patients who suffered CA while being followed up in the ED, the high CPR success rates in the AED group were similar to those reported in the study by Kozacı et al. (10), whereas the low CPR success rates in the CED group differed.

Al et al.'s (18) study reported that, among the patients who were brought to the ED of a university training hospital by 112 EMS ambulance teams, none of the cases survived. They gave no data on the ROSC rates, nor could we identify any data sources in the current literature comparing the ROSC rates of the patients admitted by 112 EMS ambulance in different ED designs. The age and gender distribution of the cases in our study was similar to that of Al et al. (18), and no statistically significant difference was noted between the two types of EDs among the cases admitted by 112 EMS ambulances in terms of ROSC.

Sittichanbuncha et al. (12) reported that shockable initial rhythms through both ventricular fibrillation (VF) and pulseless ventricular tachycardia (PVT) were associated with a good prognosis for CPR. In a meta-analysis of 143 000 patients who suffered CA, CPR at the scene, the achievement of ROSC and the detection of shockable rhythms (VF and PVT) were reported as good prognostic factors (19). In Gwinnutt et al. (20), the initial rhythms were found to be VF and PVT in 31% of the cases, and 42.2% of those cases were discharged from the hospital. In the present study, no statistically significant difference was noted between the CED and AED groups in terms of the initial rhythms, and in cases of VF and PVT as initial rhythms, the results were better in terms of achieving a ROSC following CPR. These findings suggest that the AED layout with a specific team composition and equipment increases the success rates of CPR, regardless of the initial rhythm. Initial rhythms were found to be associated with ROSC rates in the CED group, and this difference can be attributed to the fact that ROSC was achieved in a single PVT case, resulting in a CPR success rate of 100%. However, there was no such difference in the AED group. The similarities between the two groups in terms of the demographic data of the patients, duration of CPR, means of admission to the ED and initial rhythm led the authors to conclude that CEDs and AEDs can be more reliably compared in terms of the CPR success rate.

The study was conducted in a single facility, and this is one of its limitations. There are no data on the presence of basic life support or ACLS efforts in the pre-hospital period. In addition, comorbid conditions of the patients who were under observation in the EDs could not be found in the medical records.

This study showed that CED layouts may be associated with lower CPR success rates compared with AED layouts. However, beyond the ED's architectural design, the results may also have been associated with the composition of the team and the available equipment. Decision makers at an administrative level should be encouraged to adopt a standard design for EDs and hospitals that is integrated with pre-hospital EMSs.

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Conflict of Interest: The authors declare that they have no competing interests.

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