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Manual versus mechanical chest compression in in-hospital cardiac arrest: A retrospective cohort in emergency department patients

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Abstract:

OBJECTIVE: Mechanical chest compression (CC) devices are frequently used in in-hospital and out-of-hospital settings. In this study, mechanical and manual CC in in-hospital cardiac arrest was compared in terms of survival.

METHODS: Adult patients who were admitted to the emergency department (ED) for 2 years period and had cardiac arrest in the ED were included in this retrospective, observational study. Return of spontaneous circulation (ROSC), 7-day and 30-day survival and hospital discharge data were compared between the two groups of patients who underwent manual CC and those who had mechanical CC with the Lund University Cardiac Assist System-2 device.

RESULTS: Although the rate of ROSC in the mechanical CC group was lower than in the manual CC group, this difference was not statistically significant (41.7% vs. 50.4%; P = 0.133). The 7-day survival rate was found to be statistically significantly higher in the mechanical CC group (19.4% vs. 8.9%; P = 0.012). The 30-day survival rate was also found to be high in the mechanical CC group, but this difference was not statistically significant (10.6% vs. 7.3%; P = 0.339).

CONCLUSION: In the light of these results, we can say that the use of piston-based mechanical CC devices in ED may be beneficial. More reliable results can be obtained with a prospective study to be performed in the ED.

Keywords:

Cardiac arrest, chest compression, emergency department, manual, mechanical, resuscitation

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Introduction

The incidence of in-hospital cardiac arrest (IHCA) is expressed as 1–13.1/1000 admissions.[1] IHCA cases generally have a shorter time to reach medical care than out-of-hospital cardiac arrest (OHCA); however, IHCA cases are confronted with poor outcomes and high mortality rates. In large-scale studies, IHCA survival rates are expressed around 20%. IHCA remains somewhat neglected issue when compared to OHCA and vascular diseases such as stroke, and myocardial infarction.[2]

In IHCA, effective chest compressions (CC) and early defibrillation are the most important points.[3-5] It has been stated that the manual technique can only be performed

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Box-ED

What is already known on the study topic?

There is no clear evidence yet that mechanical chest compression (CC) has an effect on long-term survival.

What is the conflict on the issue? Has it important for readers?

As far as we could detect in the literature, it is the only study evaluating the effectiveness of mechanical CC devices in cardiac arrest cases in emergency department settings.

How is this study structured?

This was a single-center, retrospective observational study.

What does this study tell us?

The 7-day survival rate was found to be statistically significantly higher in the mechanical CC group. In addition, the 30-day survival rate was found to be high in the mechanical CC group; but this difference was not statistically significant.

optimally in 45% of OHCA and these wrong practices decrease the success of resuscitation.[6,7] Piston-based and load distribution band devices are the most commonly used devices which can perform CC at the optimal depth and speed with minimal intervals.[7] Lund University Cardiac Assist System-2 (LUCAS-2) device was used in this study.

There is no clear evidence yet that mechanical CC has an effect on long-term survival. It is seen in the literature that the majority of studies were conducted for OHCA cases.[8] Few studies have evaluated the effectiveness of these devices in IHCA cases.[9-14] In this study, we compared CC performed with the LUCAS-2 device with CC performed manually using our retrospective data on IHCA cases in the emergency department (ED).

Methods

This retrospective cohort study was conducted on patients who were admitted between January 2016 and January 2018 in the ED of a tertiary referral center. All interventions for patients are performed on portable patient stretchers.

Patients in the adult age group (≥18 years of age) who had cardiac arrest during ED follow-up were included in this study and those who had cardiac arrest before admission and/or cardiopulmonary resuscitations (CPRs) performed outside of the ED, under 18 years of age, who are pregnant, and were not suitable for LUCAS-2 (too large or small body size) were excluded. The LUCAS-2 device was included in the ED inventory on January 15, 2017. Based on this date, two groups have been designed; manual CC technique was used in all patients admitted between January 1, 2016, and December 31, 2016, mechanical CC technique was used in patients admitted between January 15, 2017, and January 15, 2018, with the LUCAS-2 device.

The mechanical CC was performed with the LUCAS-2 CC System. This device is put into use to eliminate handicaps such as insufficient depth of compression and long interruptions, which are thought to be caused by manual CC. It is stated that LUCAS-2 provides compression at a speed of at least 100/min and at least 4–5 cm depth as a standard. LUCAS-2 system consists of a small backboard that acts as a support at the bottom, a rechargeable battery and compression mechanism. While compressing with the silicon suction cup located at the end of the compression mechanism, it also provides active decompression.

Data on the insertion time of the LUCAS-2 device to the patient are not available in this study. However, subjectively, we can express this time as seconds in the resuscitation room, and as 1–2 min in maximum outside the resuscitation room, since the device is brought to the patient's side. In any case, we should also state that manual resuscitation was carried out until the placement of LUCAS-2.

The demographic data of the patients, the initial rhythm, and the duration of CPR were recorded and analyzed. Patients with ST elevation or critical lesion on coronary angiography (pre-arrest or after Return of spontaneous circulation [ROSC]), or troponin positivity with chest pain at admission were considered in the cardiac group, and patients with a suspected or definite focus of infection and meeting the criteria for systemic inflammatory response syndrome were considered in the septic group.

ROSC, 7/30-day survival, and discharge with survival rates were analyzed as the primary outcome. In this study, ROSC was defined as the ability to maintain the pulse detected from the carotid or femoral region for at least 5 min after the return. The data were collected from the hospital information management system and ED patient examination forms over a period of 3 months retrospectively.

Ethical approval for this study was obtained from the local ethics committee of the Yildirim Beyazit University Faculty of Medicine (25.06.2018/154). Informed consent was not obtained from the patients due to retrospective design. The study was conducted in accordance with the principles of the World Medical Association Declaration of Helsinki.

Statistical analysis

Statistical analysis was performed with SPSS Statistics for Windows, version 16.0 (SPSS Inc., Chicago, Ill., USA).

Frequency distributions of ordinal data were analyzed using the Pearson Chi-Square test. The distribution analysis of continuous data was evaluated using the Shapiro–Wilk test. Mann–Whitney-*U*-test was used for the analysis of the median of the data that did not comply with the normal distribution, and the Independent Samples-*t*-test was used to compare the means of the normally distributed data. $P < 0.05$ level was accepted for statistical significance.

Results

A total of 303 patients were included in the study; manual CC was applied to 123 (40.6%) and mechanical CC was applied to 180 (59.4%) of them. Patients in the two groups show a homogeneous distribution in terms of demographical parameters [Table 1]. The median age (interquartile range) was found to be 77 (21) and 75 (21.75) in the manual and mechanical CC groups, respectively. Although the female gender was higher in the manual CC group (52.8% vs. 43.9%). It was observed that 73.9% of the whole group were over 65-year-old [Table 1].

The comparison of vital findings is shown in Table 2. In laboratory analysis, sodium level was statistically significantly higher in the manual group (Median: 138 vs. 135 mEq/L; $P = 0.008$); there was no significant difference between the two groups in terms of other laboratory parameters (white blood cell, hemoglobin, hematocrit, platelet, glucose, urea, potassium, albumin, international normalized ratio, and troponin) ($P > 0.050$). The respiratory rate was found to be significantly higher in the mechanical CC group and the body temperature in the manual CC group [Table 2]. When the etiology of cardiac arrest was analyzed, it was seen that infective causes and cardiac causes were most frequently encountered [Table 3].

The rate of ROSC (in total: $N = 137$; 45.2%) in the mechanical CC group was lower than the manual CC group, this difference was not statistically significant (41.7% vs. 50.4%; $P = 0.133$). The 7-day survival rate (in total: $N = 46$; 15.2%) was found to be statistically significantly higher in the mechanical CC group (19.4% vs. 8.9%; $P = 0.012$). The 30-day survival rate (in total: $N = 28$; 9.2%) was again found to be higher in the mechanical CC group, but this difference was not statistically significant (10.6% vs. 7.3%; $P = 0.339$) [Table 3]. These analyses were repeated in patients with atraumatic cardiac arrest subgroup, and similarly, the 7-day survival rate was found to be statistically significantly higher in the mechanical CC group and no statistically significant difference was found in the ROSC and 30-day survival rates [Table 3].

In the analysis performed by dividing the patients into two groups as young (<65 years) and elderly (65 years), the 30-day survival rate was higher in the young group (12.7% vs. 8.0%), but this difference was not statistically significant ($P = 0.087$). In the patient group with at least one comorbid disease, the 30-day survival rate was found to be higher (10.3% vs. 6.7%) compared to those without; however, this difference was not found to be statistically significant ($P = 0.315$). While 30-day survival was 9.8% in atraumatic patients, it was 0.0% in the traumatic group. Survival was significantly higher in the group with initial arrest rhythm VF/pulseless

Table 1: Demographic features

Parameters	CPR groups, *n* (%)		Chi-square test-*P*
	Manual	Mechanical	
Age			
Median (IQR)	77 (65-86)	75 (62.25-84)	0.238*
Minimum-maximum	18-97	23-98	
≥65 years	94 (76.4)	130 (72.2)	0.413
Gender			
Female	65 (52.8)	79 (43.9)	0.125
Season			
Spring	31 (25.2)	50 (27.8)	0.549
Summer	26 (21.1)	28 (15.6)	
Autumn	29 (23.6)	39 (21.7)	
Winter	37 (30.1)	63 (35.0)	
Shift			
8-16	47 (38.2)	63 (35.0)	0.755
16-24	43 (35.0)	62 (34.4)	
24-08	33 (26.8)	55 (30.6)	
CAD	39 (31.7)	50 (27.8)	0.461
DM	33 (26.8)	41 (22.8)	0.420
HT	37 (30.1)	65 (36.1)	0.275
CVD	10 (8.1)	10 (5.6)	0.375
COPD	10 (8.1)	18 (10.0)	0.571
LTOT	8 (6.5)	10 (5.6)	0.732
PTE	2 (1.6)	5 (2.8)	0.512
CA	12 (9.8)	30 (16.7)	0.087
CKD	12 (9.8)	26 (14.4)	0.226

*Mann-Whitney-U test. CPR: Cardiopulmonary resuscitation, IQR: Interquartile range, CAD: Coronary artery disease, DM: Diabetes mellitus, HT: Hypertension, CVD: Cerebrovascular disease, COPD: Chronic obstructive pulmonary disease, LTOT: Long-term oxygen therapy, PTE: Pulmonary thromboembolism, CA: Malignancy, CKD: Chronic kidney disease

Table 2: Vital signs

Vital signs	CPR groups-median (IQR)		Mann-Whitney -U test-*P*
	Manuel	Mechanical	
SBP (mmHg)	110 (90-120)	101 (83.5-121.5)	0.908
DBP (mmHg)	61 (50-80)	64 (50-80)	0.583
HR (/min)	110 (81.75-120)	100 (85-120)	0.087
BT (°C)	36.3 (36.1-36.6)	36.0 (36.0-36.4)	<0.001
$SatO_2$ (%)	90 (84-94)	91 (85-95)	0.331
RR (/min)	18 (14-22)	24 (18-30)	<0.001
Glucose (stick)	150 (102.25-220.5)	170 (113-261)	0.162
GCS	14 (8-15)	13 (11-14)	0.277

IQR: Interquartile range, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, HR: Heart rate, BT: Body temperature, SatO2: Oxygen saturation, RR: Respiratory rate, GCS: Glasgow Coma Scale, CPR: Cardiopulmonary resuscitation

Table 3: Main parameters

Parameters	CPR groups		Chi-square test-*P*
	Manual, *n* (%)	Mechanical, *n* (%)	
Etiology			
Septic	36 (29.3)	60 (33.3)	0.250
Cardiac	18 (14.6)	39 (21.7)	
Trauma	8 (6.5)	10 (5.6)	
Undefined	61 (49.6)	71 (39.4)	
Traumatic	8 (6.5)	10 (5.6)	0.732
Initial arrest rhythm			
Asystole/PEA	102 (82.9)	134 (74.4)	0.081
VF/pulseless VT	21 (17.1)	46 (25.6)	
CPR duration >20 min	68 (55.3)	81 (45)	0.079
CPR duration (min)-median (IQR)	35 (10-45)	20 (10-45)	0.279*
All patients			
ROSC	62 (50.4)	75 (41.7)	0.133
7-day survival	11 (8.9)	35 (19.4)	0.012
30-day survival and/or discharge	9 (7.3)	19 (10.6)	0.339
Atraumatic group (*n*=285)			
ROSC	59 (51.3)	73 (42.9)	0.184
7-day survival	11 (9.6)	34 (20.0)	0.020
30-day survival and/or discharge	9 (7.8)	19 (11.2)	0.420

*Mann Whitney-U test. PEA: Pulseless electrical activity, IQR: Interquartile range, ROSC: Return of spontaneous circulation, VF: Ventricular fibrillation, VT: Ventricular tachycardia

VT compared to the group with asystole/National Education Association (16.4% vs. 7.2%; $P = 0.022$). 30-day survival was found to be statistically significantly lower in the group with a CPR duration of more than 20 min compared to the group with a maximum of 20 min (2.0% vs. 16.2%; $P < 0.001$).

Discussion

Mechanical CC devices are tools developed to be an alternative to manual CC. These devices are considered to be useful in overcoming the fatigue problem of CPR practitioners and performing CC at standard speed and depth.[15] In another aspect, some complications related to these devices are mentioned in the literature such as pneumothorax, rib fracture, and organ injuries.[14,16,17] Another important point is that the vast majority of studies so far have been conducted on OHCA cases; studies on IHCA cases are limited.

In this study, the effect of manual and mechanical CC performed with the LUCAS-2 device in a group of adult patients with cardiac arrest during ED follow-up was analyzed retrospectively. As far as we can determine, this is the first study conducted specifically for the ED setting. In this study, mechanical CC was not superior to manual CC in terms of ROSC, 30-day survival, and discharge parameters in cardiac arrest patients. However, mechanical CC seems superior to manual CC in terms of 7-day survival.

Studies have shown a wide spectrum of results, such as 0%–42%, in terms of survival at discharge rate.[2] In large-scale studies, this rate is found to be around 20%.[2] In this study, survival at discharge rate was found to be 9.2% in all patients. We think that the reasons for this low rate compared to recent studies include the ED conditions, the inclusion of trauma, older age, different diagnosis, different treatment methods in the different intensive care units, and the fact that the "do-not-resuscitate" order was not applied. Cardiac causes are the most frequent reason of cardiac arrest in the literature.[2] In the results of our study, it was seen that septic (infective) causes were at the forefront. The intensive admission of elderly home care patients with high comorbidities to our hospital may be the reason for this situation.

OHCA cases have been analyzed more frequently on this issue. In the meta-analysis published by Gates *et al*., it was stated that mechanical CC devices do not have any benefit in terms of ROSC, 30-day survival, and good neurological outcomes in OHCA cases.[18] In the meta-analysis of Liu *et al*. in 2019, it was stated that there was no statistically significant difference between manual CC and LUCAS in OHCA cases in terms of good clinical outcomes.[19] In the meta-analysis of Couper *et al*., it was stated that the use of mechanical CC devices in IHCA cases was associated with improved hospital and 30-day survival. Although the level of evidence is low, 3 randomized controlled trials and 1 observational study evaluated in this meta-analysis stated that the use of mechanical CC was associated with short-term survival.[11] Halperin *et al*. and Timerman *et al*. included in this meta-analysis reported a relationship between mechanical CC and improvement in coronary perfusion.[20,21] In addition, Parnia *et al*. found

a relationship between mechanical CC and increased cerebral oxygenation with low evidence.[11,22] In the meta-analysis published by Couper *et al*., it is stated that there are more positive results in IHCA than in OHCA reviews. It is stated that this difference may be primarily related to the low levels of evidence in this meta-analysis, and the ease of using mechanical devices in the hospital environment. In addition, it is stated that ED studies are excluded in this meta-analysis. Hock Ong *et al*. achieved better neurological outcomes and survival rates in their study in the ED using a mechanical CC device based on a load-distributing band and the majority of cases were patients who entered the ED in cardiac arrest.[23] In our study, we excluded the patients entering the ED as cardiac arrest. Another issue is that the soft layer under the patient reduces the effectiveness of CC in IHCA cases with manual CC. This factor is ruled out a little more because of the stiffer stretchers in the ED. ED and other in-hospital ward settings are not similar. EDs are environments where standardization can be achieved at an optimal level, usually due to the sufficient number of personnel and equipment. We can say that this advantage may also be in question in our study settings and affect the main outcomes.

Similar to the literature,[24] the low survival rate (8%) in the group over 65 years of age is remarkable. The hospital, where the study was conducted, is an advanced training and research hospital where patients with high comorbidity are referred; these low survival rates can be explained by this situation. In the study of David *et al*. survival rates of the trauma and medical arrest, groups were found to be statistically similar.[25] Unlike this study, all our patients in the trauma group ($n = 18$) were observed not to have survived at 30 days. In addition, better survival rates in cases presenting with shockable rhythms are similar to the literature (supported the early defibrillation). Contrary to this statement, it should be taken into account that in our study survival in cardiac arrests with a CPR duration of more than 20 min was extremely low. However, it is not appropriate to make a recommendation about the duration of CPR with these study results.

Limitations

The main limitations of our study are its retrospective design and being a single center study. As this study is limited to the ED, it may not fully simulate out-of-hospital and other in-hospital areas due to different conditions related to the soft layers in in-hospital areas and the stiff trauma board layers in out-of-hospital areas. It is also considered important that the etiology of the cardiac arrest cannot be clarified in most of the patients of both two groups, due to the ED conditions. Finally, data on CC complication rates are not available in this study.

Conclusion

This IHCA study is actually the first study on this subject specific to the ED environment. As a result, although there is no significant difference between mechanical CC performed in the ED compared to manual CC in terms of ROSC, it has been observed that mechanical CC provides statistically significantly higher 7-day survival rates. On the other hand, the 30-day survival rate was higher in the mechanical CC group, but the difference was not statistically significant. These confusing results may be due to the advanced age and the high rate of uncertain and/or septic etiologies. COVID-19 patients were not discussed in this study due to the period it was conducted, we think that the use of mechanical CC devices in patients with COVID-19 should be seriously evaluated in order to reduce the risk of transmission.

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Author contributions
AŞ, GPG, FT, AÖ, ŞG, GKÇ, ÖS, and NE conducted the study concept and design, analysis, and interpretation of the data, drafting of the manuscript, critical revision of the manuscript for important intellectual content; AŞ conducted the statistical analysis and AŞ, ÖS and NE conducted the acquisition of the data.

Conflicts of interest
None Declared.

Ethical approval
Ethical approval for this study was obtained from the local ethics committee of the Yildirim Beyazit University Facultyof Medicine (25.06.2018/154).

Informed consent
Informed consent was not obtained from the patients due to the retrospective design.

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