Manual CPR Vs Mechanical CPR: Which One Is More Effective During Ambulance Transport?

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Abstract

Objectives

We aimed to evaluate and compare the qualities of chest compressions performed manually by healthcare professionals and by a mechanical chest compression device on a training model during an ambulance transfer. Design

This is an experimental trial.

Setting

This study was performed by the EMS of Ankara City (Capital of Turkey). 20 (10 male and 10 female) paramedic participated the study. We used LUCAS 2 as mechanical chest compression device in the study. A total of 40 rounds were driven on the track; in that moving ambulance, the model was applied chest compression in 20 rounds by paramedics, while in 20 rounds were applied by mechanical chest compression device. The depth, rate and hands-off time of chest compression were measured by means of the model's recording system.

Results

The median chest compression rate was 120.1 compressions per minute (IQR 25−75%=117.9−133.5) for the paramedics, whereas it was 102.3 compressions per minute for the mechanical chest compression device (IQR 25−75%=102.1−102.7) ($p<0.001$). The median chest compression depth was 38.9 millimeters (IQR 25−75%=32.9−45.5) for the paramedics, whereas it was 52.7 millimeters for the mechanical chest compression device (IQR 25−75%=51.8−55.0) ($p<0.001$). The median hands-off time during cardiopulmonary resuscitation was 6.9% (IQR 25−75=5.0−10.1%) for the paramedics and 9% (IQR 25−75%=8.2−12.5%) ($p=0.09$).

Conclusion

Chest compressions performed by the mechanical chest compression device were found to be within the range recommended by the guidelines in terms of both speed and duration.

1. Introduction

High-quality chest compression (HQCC) is very important for survival in cardiopulmonary arrest patients. [1] To administer HQCC, the thoracic cage must be fully loosened between compressions at sufficient depth and speed. According to the 2015 American Heart Association (AHA) Guidelines, to achieve HQCC, one must execute 100−120 chest compressions per minute at a minimum depth of 5 cm (a maximum of 6 cm) per press.[2] It is quite difficult to administer HQCC during the pre-hospital period; the skill level or number of the staff may be inadequate, the staff may be tired, there may be scene-related or patient-related problems (e.g., chest elasticity differences, vascular difficulties), and it may be difficult to apply

chest compressions in a moving ambulance. Although survival is very low after pre-hospital cardiac arrest.[3] the development of life chain steps can increase survival by up to 50%.[2]

Mechanical chest compression devices (MCCDs) are designed to provide chest compressions at an appropriate depth and frequency without causing fatigue.[4] According to studies on the pre-hospital period, there is no difference between manual cardiopulmonary resuscitation (CPR) and MCCD-administered CPR in terms of hospital discharge and 30-day survival rates.[5,6]

Although there are studies on the pre-hospital period comparing the survival and hospital discharge rates achieved after manual CPR versus MCCD-administered CPR, there are not many studies that measure the quality of CPR during this period. The main problem with pre-hospital cardiac arrest cases is the transport of the patient to the hospital. Sudden braking or acceleration of the ambulance and a decrease in CPR efficiency as the ambulance travels through road bends are important challenges. These challenges experienced by healthcare professionals during transport cause pauses in the CPR.[7] Administering CPR during ambulance transports also endangers the safety of healthcare professionals.

In this study, we aimed to evaluate and compare the qualities of chest compressions performed manually by healthcare professionals and by an MCDD on a training model during an ambulance transport.

2. Methods

This study was performed experimentally by the EMS of Ankara City (the capital of Turkey). Ethics committee approval of the study from University of Health Science, Turkey.

a. Characteristics of the Participants

Twenty paramedics—each of which had at least five years of field experience in the EMS of Ankara City and had completed the four training modules of the Ministry of Health (MoH) of the Republic of Turkey—were included in this study on a voluntary basis. The paramedic participants were allowed to get used to the training model by practicing on it for 10 minutes before the study. Participants were asked to apply chest compressions to the training model (in accordance with the 2015 AHA guidelines) within the moving ambulance. All safety measures were taken to prevent the paramedic participants from skidding, falling, or being injured while administering chest compressions (Fig. 1).

b. Characteristics of the Ambulance Driving Track

The points where paramedics would have difficulty to perform CPR in the ambulance had been pre-evaluated. To prevent these difficulties in advance, a driving track for ambulance driving training was simulated in accordance with the national standards of the MoH of Turkey and the actual conditions. The driving track is designed to help drivers practice evasive maneuvering, parking, slalom, swiveling, and panic braking. The width of the driving track was 1.5 meters, and its total length was 269 meters (Fig. 2).

The study was originally intended to be carried out on a city traffic route instead of a simulated driving track. However, since the volume of traffic could not be standardized, it was finally decided to carry out the study on this driving track.

c. Characteristics of the Ambulance

In this study, a fully equipped training ambulance (Mercedes Sprinter®, 2015, Germany) from the EMS of Ankara City was used. To ensure standardization, the ambulance was driven by the same ambulance driving trainer each time. Before the start, the driver was allowed to take five practice laps to get used to the driving track. During the study, the drivers were asked to go as fast as they could, but they reached a maximum speed of 20 km per hour to ensure ambulance paramedics safety. The speed was up to 40 km / h on the straight-ahead route, while the maximum speed was 20 km / h in the maneuvering areas.

d. Characteristics of the CPR Training Model

The Simman 3 training model (Laerdal®, Stavanger, Norway 2014) was used to measure the speed of the chest compressions and the duration of the interruptions between them, which are indicators of CPR quality. While the ambulance was driven on the track, the paramedic or the MCCD performed chest compressions on the model. The MCCD was fixed to the model by using belts to prevent it from sliding over the model. The model was fixed to the ambulance stretcher by a three-point climbing belt to prevent the model from sliding. Chest compressions were started immediately when the ambulance began to move. The training model recorded the chest compression rate (number of compressions per minute), compression depth, and hands-off time*.

Hands-off time" describes the interruptions that occur during chest compression.

The LUCAS Chest Compression System (Physio-Control/ Jolife AB) was used as MCCD. MCDD was fixed to the manikin by fastening the belts. The chest compression rate of the MCCD was set to 100 / min, while its compression depth was set to 5 cm.

e. Application

In the first stage, the paramedic participants performed manual chest compressions on the model while the ambulance was moving. To assess the effectiveness of the paramedics, each of the 20 paramedics took 2 laps around the track (20 paramedics × 2 laps = 40 laps). Since the ambulance did not move straight, and maneuvered continuously, it was thought that one round would not be enough to assess the effectiveness of each paramedic. Therefore, each paramedic was asked to perform chest compression for 2 rounds. One lap of the ambulance around the track took an average of two minutes (totally 80 minutes).

In the second stage, in order to ensure the equal time and CPR conditions with paramedics, 40 more laps were driven performing chest compressions with the MCCD. To make comparisons with paramedics, at the end of each 2 laps, the number of chest compressions, the depth of compressions, and hands-off

time were recorded; the CPR process and ambulance movements were recorded by cameras placed in the front and rear cabin of the ambulance.

f. Statistical analysis

All data recorded during the study were analyzed using SPSS software version 15.0 (for Windows, Chicago, IL, USA). Categorical data were expressed as frequencies and percentages. The Kolmogorov-Smirnow test was used to determine whether the continuous data had normal distribution. Whereas the variables that were normally distributed were expressed as means and standard deviations, the variables that were not normally distributed were expressed as medians and 25–75 quarter. Student's t-test was used for parametric data, whereas the Mann–Whitney U test was used for non-parametric data. To determine the statistical significance level, the critical alpha value was defined as $p < 0.05$.

3. Results

A total of 20 paramedics (10 males and 10 females) were included in the study. The average number of years of experience for the paramedics was 7.65. The median age was 25.5 (24–30) and the median body mass index (BMI) was 23.1 (20.8–25.8) (Table 1).

Table 1
Descriptive characteristics of the participant paramedics*

Characteristics	Median	IQR 25–75%
Age	25.5 years	24–30
BMI	23.1	20.8–25.8
Height	168.0 cm	161.2–177.5
Weight	67.0 kg	55.0–81.5
*Defined as median**BMI: ***cm: centimeter ****kg: kilogram		

In this study, the median chest compression rate was 120.1 compressions per minute (117.9–133.5) for the paramedics, whereas it was 102.3 compressions per minute for the MCCD (102.1–102.7). There was a statistically significant difference between the study groups in terms of chest compression rate ($p <$ 0.001) (Table 2).

Table 2
Chest compression rate, compression depth, and hands-off time findings*

	MCCD	Paramedics	P value
Speed	102.3 compressions per min (102.1–102.7)	120.1 compressions per minute (117.9–133.5)	< 0.001
Depth	52.7 mm (51.8–55.0)	38.9 mm (32.9–45.5)	< 0.001
Hands-off time	9% (8.2–12.5%)	6.9% (5.0–10.1%)	0.09
*Values are defined as IQR and as median			

Table 3
Chest compression rate, depth, and hands-off time according to paramedic participant gender groups

	Speed*	Depth*	Hands-off time*
Female	119.2 compressions per minute (108.1–121.7)	36.4 mm (32.0–39.3)	9.2% (5.1–11.1%)
Male	133.1 compressions per minute (119.7–141.5)	43.7 mm (33.9–47.4)	5.5% (0–8.4%)
P value	0.015	0.14	0.24
*Values are defined as IQR and as median; *mm: millimeter			

The median chest compression depth was 38.9 mm (32.9–45.5) for the paramedics, whereas it was 52.7 mm for the MCCD (51.8–55.0). There was a statistically significant difference between the study groups in terms of chest compression depth (p < 0.001) (Table 2).

The median hands-off time during CPR was 6.9% (5.0–10.1%) for the paramedics and 9% (8.2–12.5%) for the MCCD. There was no statistically significant difference between the study groups in terms of hands-off time during CPR (p = 0.09) (Table 2).

4. Discussion

Cardiac arrest patients should be treated as soon as possible. Performing high-quality CPR at the scene and during transport is very important for these patients. Although it is relatively easy to administer CPR at the scene, it is quite difficult to administer CPR in a moving ambulance during a transport. The sudden

accelerations, decelerations, and centrifugal forces in moving ambulances are the factors that make it difficult for paramedics to perform CPR. In order to avoid these factors, the use of MCCDs in pre-hospital emergency medical systems was investigated, and there was no statistically significant difference in the patient survival rates attained after manual CPR applications and MCCD use.[1,5,6] However, there are not many studies that examine CPR quality during the pre-hospital period. In our study, we aimed to measure and compare the quality of CPR performed by paramedics and by an MCDD in a moving ambulance for out of cardiac arrest patients.

The current adult cardiac life support guidelines recommend 100–120 chest compressions per minute. It has been shown that a rate faster than 120 compressions per minute reduces the compression depth and therefore reduces venous return to the heart, coronary perfusion pressure, and myocardial blood supply. In our study, the compression speed of the paramedics was at the upper limits indicated in the CPR guidelines, whereas the compression speed of the MCCD was within the specified range. According to a study investigating CPR quality during patient transport by helicopter, the median compression rate was reported as 100 ± 0.5 compressions per minute for MCCD and 113 ± 6 compressions per minute for paramedics.[8] In the aforementioned study, the manual compression rate may have been in the targeted range because helicopters provide a more stable setting than land ambulances, and sudden movements are less frequent in helicopters. In another study conducted in Denmark, chest compressions of MCCDs and paramedics while transferring patients to hospital were compared. It was determined that MCCDs applied chest compressions at the rate specified in guidelines, whereas paramedics performed chest compressions faster than recommended by guidelines.[9] We think that the reason why paramedics perform chest compressions faster in mobile environments is that they protect themselves from the effect of skidding by making more contact with the patient during compression.

We found that the compression depth achieved by the paramedics was lower than that achieved by the MCCD. According to a study by Yuksen et al., there was no difference between the depth of the CPR compressions obtained in a stable setting by MCCD and that obtained by a healthcare professional.[10] Similar to our study, Fox et al. found that paramedics performed the appropriate chest compression depth by 67%.[11] In two different studies, the compression application difference between EMS professionals and two different automated-CPR devices was evaluated, and the compression depth provided by automated-CPR devices was found to be more appropriate than those of paramedics.[12,13] We believe that the paramedics achieved a lower depth of compression because the ambulance was not a stable environment. The driving track of our study included harsh conditions that required stop-and-go, reverse maneuvers, slalom, and the paramedics were jarred by skidding in the ambulance. In our study, faster chest compressions performed by the paramedics may have caused a decrease in depth. As stated in the literature, faster chest compressions cause a decrease in compression depth.

In a study by Olasveengen et al. comparing MCCD with manual CPR during transport, MCCD's hands-off time was found to be 8% of the entire CPR process, while it was 27% in paramedics.[14] In another study, while the hands-off time was 8.6 seconds during manual CPR, MCCD (LUCAS-2) performed uninterrupted

CPR.[15] In our study, no significant difference was found between the paramedics and the MCCD in terms of hands-off time. Although we fixed the MCCD to the model, it slipped over the model during the movement and lost its position; we believe this is why no difference was found.

In the literature, no significant difference was found between MCCD-administered CPR and manual CPR in terms of survival and neurological damage.[4–6, 16–18] Survival results have been demonstrated in large randomized clinical trials; however, the effect of CPR quality on patient outcome is not discussed. It is emphasized that CPR quality is the most important factor affecting survival. However, there are not many studies in the literature that compare the quality of CPR achieved by MCCD and that achieved by healthcare professionals. We believe that our study is important because it demonstrates that the quality of MCCD-administered CPR during ambulance transports is better than that of manual CPR.

Limitations

The most important limitations of our study are the number of manual CPR samples, the duration of CPR administration and the maximum speed of ambulance. Our study was carried out on a driving track, not in real city traffic during a real patient transport (so as not to endanger the safety of any drivers, pedestrians, or healthcare professionals). However, it is certain that the ambulance will be faster and less controlled during a real hospital transport, a factor that may make MCCD administered CPR a better choice.

Conclusion

In our study, the CPR quality indicators which are an important factor in patient survival of manual CPR and MCCD-administered CPR performed during patient transport in an EMS ambulance were evaluated. Chest compressions performed by the MCCD were found to be within the range recommended by the guidelines in terms of both speed and duration. In clinical studies on CPR, the use of MCCD in pre-hospital EMS transports should be evaluated.

Declarations

References

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Figures

Figure 1

Application of chest compressions to the training model in an ambulance by paramedics and the safety measures taken
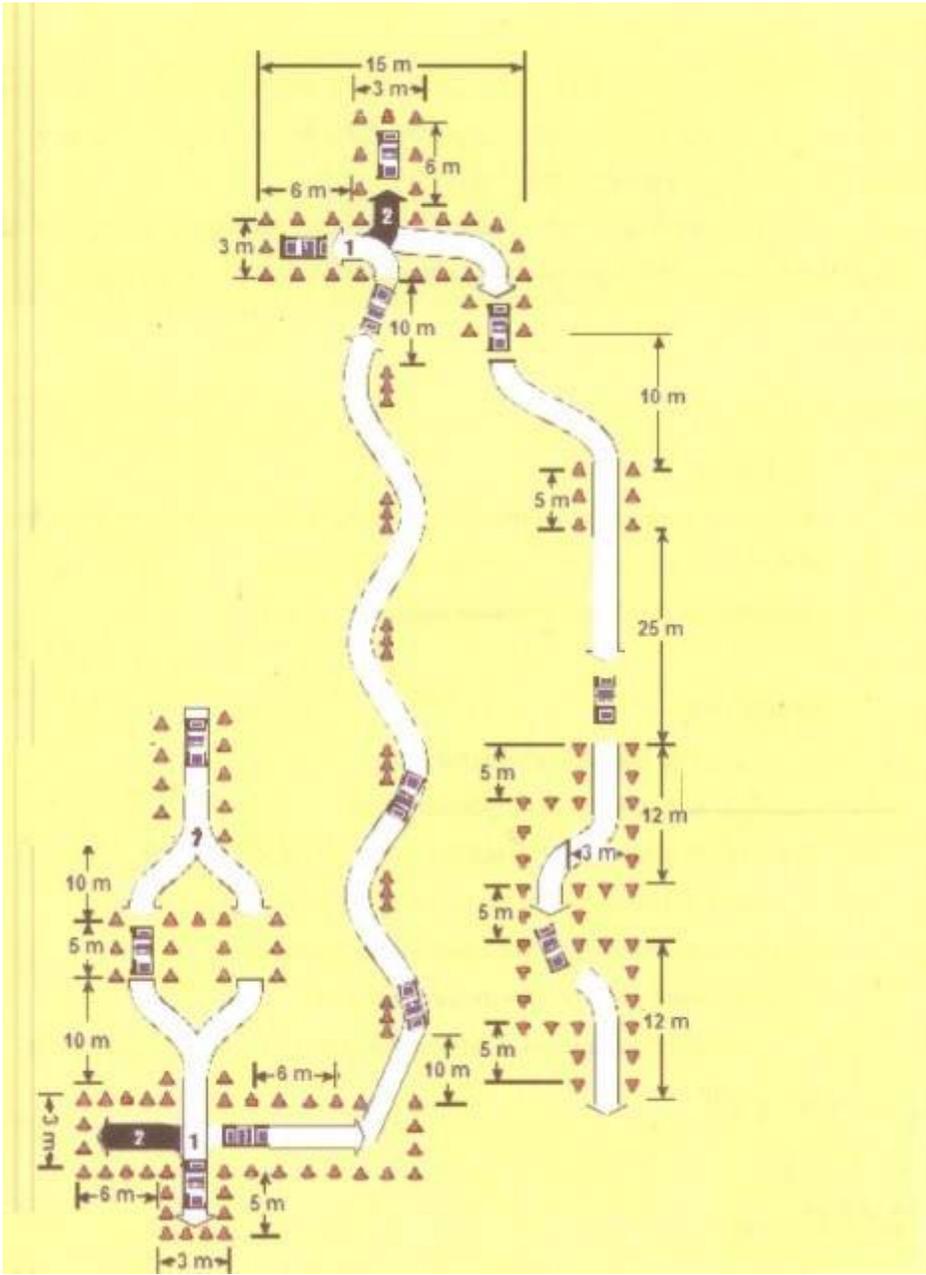
Figure 2

Ambulance-driving training track of the city of Ankara, Ministry of Health in the Republic of Turkey;
*m:meter