RESEARCH ARTICLE

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Effectivity Comparison Between Mechanical Chest Compression and Manual Chest Compression in Real Urban Traffic

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Objective: The most significant factor that increases the survival rate in out-of-hospital sudden cardiac arrest cases is cardiopulmonary resuscitation, which is started early and performed effectively. The present study aims to compare the effectiveness of manuel chest compressions applied by healthcare workers to the effectiveness of a mechanical chest compression device in an ambulance moving in real urban traffic.

Materials and Methods: The thirty healthcare workers were asked to perform chest compressions in different chest wall stiffnesses on manikin in ambulance. During chest compressions, the ambulance was continuously under way in real urban traffic. Then, a mechanical chest compression device was placed on the manikin and chest compressions were performed under the same conditions. Average speeds and depths of chest compressions for each cycle were recorded with a computer program.

Results: The median chest compression depths of healthcare workers group and mechanical chest compression device group were 52 mm and 55 mm at 6 nm chest wall stiffness and 42 mm and 51 mm at 11 nm nm chest wall stiffness. When the number of compressions per minute was examined, the median value was 102 /min in both groups at 6 nm chest wall stiffness and 85 /min and 101/min at 11 nm chest wall stiffness.

Conclusion: Mechanical chest compression device provides more effective chest compression during transport when compared to manual compression. The effectiveness of mechanical chest compression increases in patients with high body mass index.

Key Words: *Emergency medical services, ambulances, resuscitation, moving and lifting patients*

Gerçek Şehir Trafiğinde Mekanik Göğüs Kompresyonu ile Manuel Göğüs Kompresyonu Arasında Etkinlik Karşılaştırması

Amaç: Hastane dışı ani kardiyak arrest vakalarında sağkalım oranını artıran en önemli faktör, erken başlatılan ve etkin bir şekilde uygulanan kardiyopulmoner resüsitasyondur. Bu çalışma, gerçek şehir trafiğinde hareket eden bir ambulansta, sağlık çalışanları tarafından uygulanan manuel göğüs kompresyonlarının etkinliğini ile mekanik bir göğüs kompresyon cihazının etkinliği ile karşılaştırmayı amaçlamaktadır.

Gereç ve Yöntem: Otuz Sağlık çalışanından ambulanstaki mankene farklı göğüs duvarı sertliklerinde 2 dakikalık göğüs kompresyonları yapmaları istendi. Göğüs kompresyonları sırasında, ambulans gerçek şehir trafiğinde sürekli hareket halindeydi. Ardından manken üzerine mekanik bir göğüs kompresyon cihazı yerleştirilip aynı şartlarda göğüs kompresyonları yaptırıldı. Her döngüye ait göğüs kompresyonlarının ortalama hız ve derinlikleri bilgisayar programı ile kaydedildi.

Bulgular: Sağlık çalışanı grubu ve mekanik göğüs kompresyon cihazı grubunun ortanca göğüs kompresyon derinlikleri sırasıyla; 6 nm göğüs duvarı sertliğinde 52 mm ve 55 mm ve 11 nm göğüs duvarı sertliğinde 42 mm ve 51 mm ölçüldü. Dakikadaki sıkıştırma sayısıları incelendiğinde, her iki grupta 6 nm göğüs duvarı sertliğinde 102 /dk, 11 nm göğüs duvarı sertliğinde 85 /dk ve 101 /dk idi.

Sonuç: Sonuç olarak, mekanik göğüs kompresyon cihazları taşıma sırasında sağlık çalışanlarına kıyasla daha etkili göğüs kompresyonu sağlar. Yüksek vücut kitle indeksi olan hastalarda mekanik göğüs kompresyon cihazının etkinliği daha fazladır.

Anahtar Kelimeler: *Acil tıbbi servisler, cankurtaranlar, canlandırma, hastaların hareket ettirilmesi ve kaldırılması*

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Introduction

Out of hospital sudden cardiac arrest is one of the leading causes of death in the world. Today, the survival rate of out-of-hospital sudden cardiac arrest is relatively low (1, 2). Neurological sequelae are observed in 90-95% of surviving patients (3). The most significant factor that increases the survival rate in out-of-hospital sudden cardiac arrest cases is cardiopulmonary resuscitation (CPR), which is started early and performed effectively. Because the continuity of perfusion of vital organs can only be achieved by effective resuscitation (2, 4, 5). The crucial point in effective CPR is to perform chest compression at a sufficient number (100-120/min) and depth (50-60 mm) (6-9). Due to the limited availability of healthcare workers and adverse environmental conditions, effectiveness is generally low in CPRs during transport or out-of-hospital cases (10, 11).

Effective chest compression can be performed for the desired duration with mechanical chest compression devices (MCCD). Transport conditions such as carrying on a stretcher or with an ambulance affect the number and depth of chest compression applied to the patient. These devices are thought to allow for effective chest compressions during transport. Chest compression with an MCCD is uninterrupted because it does not require a replacement of the rescuer (12). MCCD is theoretically more effective because it is independent of the rescuer (12). Mechanical chest compression devices are also safer for the transport team, who operate in a moving ambulance.

This study aims to compare chest compressions performed by healthcare professionals with chest compressions performed by an MCCD. Both compressions are performed in an ambulance on the move in real city traffic.

Materials and Methods

Our study was conducted in an ambulance on the move at a crowded city (İzmir) with approximately 4.5 m population at Western Turkey. As the route, the main streets of the city, which are about 10 km long were chosen at the rush hour period. Local ethics committee permission (from Izmir Bozyaka Training and Research Hospital Clinical Research Ethics Committee at 05.07.2017/5) and other necessary permissions were obtained before the study.

The study was carried out with 30 paramedics who attended the training organized by the ministry of health and had a minimum of 5 years of experience. Paramedics were asked to perform chest compression on the computer-assisted resuscitation manikin (Ambu Man Manikin, Ambu, USA), in accordance with the guidelines, which was placed on the trauma board in the ambulance (Transit, Ford, 2015). The manikin had adjustable chest stiffness. 6 N/mm chest stiffness was chosen to represent patients with low body mass and/or young, and 11 N/mm for patients with high body mass and/or elder. In the first round, the manikin's chest stiffness was adjusted to 6 N/mm, and each paramedic applied chest compression for 2 minutes. In the second round, its chest stiffness was adjusted to 11 N/mm, and each paramedic applied chest compression for 2 minutes. To exclude the fatigue effect, paramedics applied chest compressions in the same order. After every 2 minutes of the cycle, the average speed and depth of the compressions of that cycle were recorded on the computer. During the compresses, the ambulance continued to move on the predetermined city route.

Then, while the ambulance was moving on the same route, a mechanical chest compression device (LUCAS 2, Jolife AB, Sweden) was placed on the manikin. 30 cycles were taken at each hardness level for 6 N/mm and 11 N/mm, respectively (each cycle were 2 minutes). Average speeds and depths of compressions for each cycle were recorded.

SPSS 25.0 (IBM Corporation, Armonk, New York, United States) and PAST 3 (Hammer, Ø., Harper, D.A.T., Ryan, P.D. 2001. Paleontological statistics) were used in the analysis of variables. While the distribution of univariate data was evaluated by the Shapiro-Wilk test, Mardia (Dornik and Hansen omnibus) test was used to test the normality of multivariate data. To compare the depth/mm and rate/minute variables of the MCCD and Paramedic groups based on the 6 N/mm and 11 N/mm data, Mann-Whitney U test, which is one of the nonparametric tests, was used together with Monte Carlo results. Wilcoxon Signed Ranks Test was used with Monte Carlo results to compare the 6 N/mm and 11 N/mm measurements of the depth/mm and rate/minute variables. Quantitative variables are shown as median (Minimum/Maximum) in the tables. Variables were examined at a 95% confidence level, and the p-value was taken as <0.05.

Results

The compression depth median value in the paramedic group was 52 mm for the 6 N/mm chest stiffness level. However, ineffective cycles (<50 mm) with a minimum of 46 mm were detected in the paramedic group. In the MCCD group, the effective depth value (50-60 mm) was measured in all cycles with a median value of 55 mm.

When the chest wall stiffness was set as 11 N/mm, the compression depth median value in the paramedic group was measured as 42 mm. In the MCCD group, effective depth value (50-60 mm) were detected in all cycles with 51 mm depth median value.

As for the number of compression per minute, the median value of the compression number in paramedic and MCCD group at 6 N/mm stiffness level was 102/min. However, ineffective cycles (<100/min) with a minimum of 95/min were detected in the paramedic group.

When the chest wall stiffness level is set to 11 N/mm, the median value of compression in the paramedic group was 85/min while it was 101/min in the MCCD group (Table 1, Figure 1-2).

Table 1. Chest wall depth and compression rate per minute by groups

	MCCD (N=30) Median (Q1 / Q3)	Paramedic (N=30) Median (Q1 / Q3)	P
Depth / mm			
6 N/mm	55 (54 / 55)	52 (46 / 59)	<0.001 [u]
11 N/mm	51 (51 / 52)	42 (34 / 53)	<0.001 [u]
P (for intra 6-11 N/mm)	<0.001 [w]	0.136 [w]	
Rate / minute			
6 N/mm	102 (101 / 102)	102 (95 / 126)	0.153 [u]
11 N/mm	101 (100 / 101)	85 (77 / 108)	<0.001 [u]
P (for intra 6-11 N/mm)	<0.001 [w]	0.020 [w]	

[u] Mann Whitney U Test (Monte Carlo), [w] Wilcoxon Signed Ranks Test (Monte Carlo), Min: Minimum, Max: Maximum, Q1: Percentile 25, Q3: Percentile 75

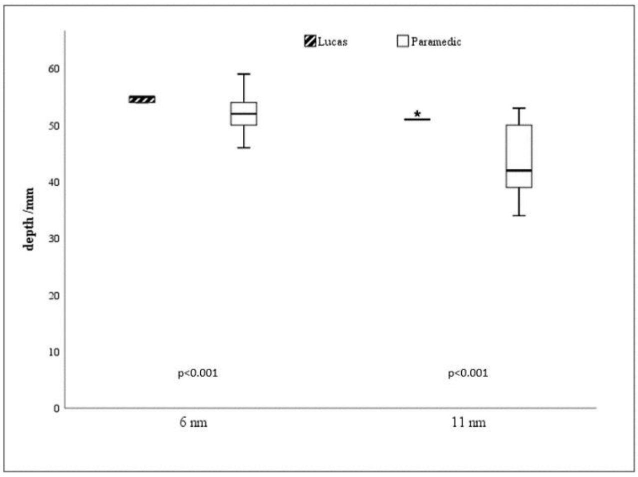

Figure 1. Chest wall depth by groups

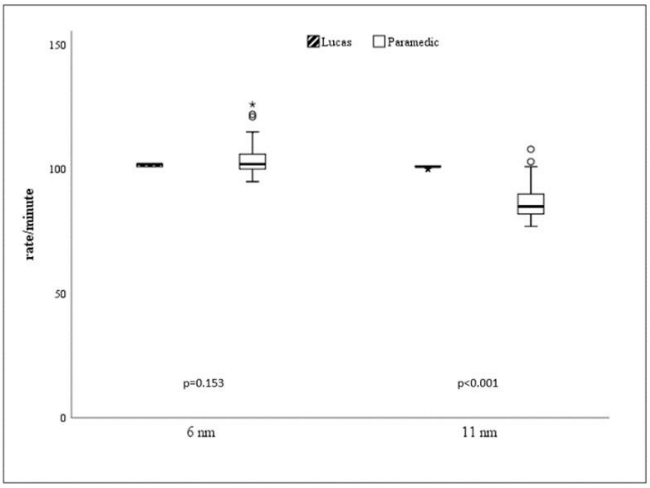

Figure 2. Chest compression rate per minute by groups

Discussion

Central nervous system perfusion is important for better neurological results in patients with return of spontaneous circulation. The desired perfusion can be achieved with quality chest compressions during CPR (13-17). The features of chest compressions are highlighted in detail in each new resuscitation guide (18). In the literature, there are studies comparing MCCD with manual compression. In the present study, MCCD is found more effective than manual compression in situations where physical conditions such as transportation are more difficult, and the workforce is limited. Gyory and et al. (19) put, "the machine does not get tired like a human and the quality of chest compressions does not decrease over time".

Although paramedics performed chest compressions for only 2 minutes, ineffective chest compressions were measured at both chest stiffness levels. We think that the reason for this is the difficulty of the physical conditions (linear-angular acceleration, vibration, shake etc.) caused by the constant movement of the ambulance (20-23). The effort made by paramedics to keep their balance in the moving ambulance negatively affects their CPR performance (24). Paramedics described doing compression in a moving ambulance as "potentially unsafe" (25). Studies have shown that the conditions such as acceleration, vibration, and shaking caused by the ambulance movement trigger reflexive movements of paramedics. These reflexive movements pose a danger to the paramedics and the patients. The use of MCCD will mitigate this danger (20, 26-29).

The patient's body mass index or thorax flexibility affects the power to be applied for effective chest compression. In the literature, there are not enough studies examining the quality of chest compressions according to the physical characteristics of the patient, such as body mass and age. Although its importance is emphasised in guidelines, we think that chest compression cannot be applied effectively (100-120/min and 50-60 mm) to patients during transport in real life. In the present study, we measured effective number and depth chest compressions in the MCCD group at both chest wall stiffness levels. There was a significant difference in median values of compression depth between the paramedic and MCCD groups for the 6 N/mm chest wall stiffness. However, in this stiffness level, ineffective number of compression and ineffective depth of compression were measured the paramedic group. In 11 N/mm chest wall stiffness, the ineffective compression difference between the groups increased significantly.

In summary, CPR quality decreases during the patient's transport (21). In such cases, it can be said that MCCD usage becomes crucial. Because when MCCD is used during transportation, the quality of the compressions can be achieved as suggested in the guidelines (13).

The strengths of our study are the experienced paramedics and the ambulance moving in real city traffic.

In limitations, the clinical effect of the compressions that we interpret as an ineffective compression (<100/min, <5mm) was not be examined since we used a manikin. The effect of fatigue on CPR was not evaluated since the paramedics performed chest compression for only 2 minutes. A manikin was used in the study, and this manikin had two chest stiffness levels. Therefore, chest compression was not evaluated in patients with different physical features (infant, child, morbid obesity, etc.). In the study, assembly time of the MCCD to the patient was not evaluated. Assembly time that affects the onset of CPR may prolong in patients with high body mass index.

As a result, MCCD provides more effective chest compression during transport when compared to manual compression. The effectiveness of MCCD increases in patients with high body mass index.

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