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Discussion of Mechanical Chest Compression Device Usage in Cardiac Arrest Cases in Hospitals in Light of Recent Literature

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Abstract

The most important goal of cardio-pulmonary resuscitation is to provide adequate blood flow to brain and heart by return of spontaneous circulation and this can be performed by chest compressions in cardio-pulmonary resuscitation. The most important fact for providing the best circulation is immediate, fast, continuous and high quality chest compression in 2015 American Heart Association (AHA) guideline. Therefore various mechanical chest compression devices are developed recently for more efficient chest compressions and entered the clinical usage. These devices may be considered for use in situations such as prolonged CPR, low number of rescuers, hypothermic cardiac arrest, ambulances in motion, extracorporeal CPR, during angiography which makes it difficult to perform high quality CPR. Apart from these conditions, mechanical chest compression devices should not be preferred to manual chest compression in in-hospital cardiac arrest cases.

Keywords: Cardiac Arrest, CPR, Device

Introduction

Mortality rate of cardiac arrests in hospital is pretty high.[1,2] While survival rates vary between 5% to 50% and varying degrees of brain damage occur in more than half of the patients who can manage to survive.[3-5] The most important goal of cardio-pulmonary resuscitation is to provide adequate blood flow to brain and heart by return of spontaneous circulation and this can be performed by chest compressions in cardio-pulmonary resuscitation. During chest compressions, the intra-thoracic pressure increases and this provides the blood to circulate through the heart. In the decompression phase intra-thoracic pressure decreases and provides return of blood to the heart.[6]

In most of the societies, the progress of the interventions after cardiac arrests cannot provide favorable outcomes or they can only provide restricted recoveries.[7,8] Lack of experience and ability with inadequate chest compressions are the most important reasons of CPR failure in many studies that investigate the reasons. Even well performed chest compressions cannot provide coronary and cerebral perfusion as good as spontaneous circulation.[6] In another study, it was shown that even a 1 minute long CPR on a mannequin causes severe fatigue. Also the rate of accurate and proper CPR decreases by time.[9] The most important fact for providing the best circulation is immediate, fast, continuous and high quality chest compression in 2015 American Heart Association (AHA) guideline.[10] Therefore various mechanical chest compression devices are developed recently for more efficient chest compressions and entered the clinical usage. In this section we aimed to inform about the CPR performed by mechanical chest compression devices in cardiac arrest cases occurred in the hospital with regards to recent knowledge. We aimed to give recent information by considering guidelines that published in last years, randomized controlled clinical and experimental studies.

Mechanical Chest Compression Devices:

Active Compression- Decompression CPR and Impedance Threshold Device

ACD-CPR is performed by manually pump that has penetration feature in mid 1/3 of the sternum. After compression phase, during the decompression phase device move away from the chest and let the blood flow back to the heart. Therefore cardiac output increases.[10]

Impedance threshold device is a valve controlled device that attached to the endotracheal tube or supraglottic airway. The device increases the negative intrathoracic pressure by limiting air flow to the lungs in decompression phase of CPR. Thus venous return to the heart and cardiac output in-

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creases. It does not prevent positive pressure ventilation and exhalation at the same time. When ROSC is achieved the device detached. It can be used individually or together with active compression-decompression CPR device.[10,11]

Coronary and cerebral perfusion increment by elevation of intrathoracic negative pressure in the decompression phase is determined in previous human and animal studies in which the CPR was performed by ACD-CPR and ITD.[12-14] Furthermore, this approach increases the 24 survival rates in clinical trials.[15,16] The study which Wik L et al that performed shows us ACD-CPR increases the short-term and long term survival rates significantly.[17] In another study there was not significant superiority at survival rates and ROSC between traditional CPR and ACD-CPR in cardiac arrest cases occurred in hospital. Only ACD-CPR caused less complications like costa fractures, hemothorax and pneumothorax.[18] But controversial conclusions are determined about ACD-CPR in various studies. Besides depending on rescuer and be obliged to change the rescuer frequently as traditional CPR are the negative sides of ACD-CPR.[19]

American Heart Association (AHA) 2015 guideline stated that there was only one poor quality randomized controlled trial about ACD-CPR and ITD. According the result of this study, routine usage of ACD-CPR and ITD was not recommended. However in the presence of educated crew and appropriate equipment the combined usage of traditional CPR and ACD-CPR should be considered (Class IIb, LOE C-LD). The routine usage of ITD in CPR was not recommended because lack of enough evidence on 2015 AHA guideline (Class III: No Benefit, LOE A).[10]

Mechanical Chest Compression Devices: Piston Device

Chest compressions performed by a piston which places onto the sternum and uses electric or gas. These compressions can be adjusted as fast as required. While some of these devices are designed with vacuum mechanism for active decompression after every compression, some of them not designed as this mechanism. The most frequent used one of these devices is LUCAS (Lund University Cardiac Assist System).[10]

LUCAS provides appropriate amplitude and appropriate rate of compression. The device works automatically and is not depended on rescuer. After compression provided the device gets the initial position which let the heart relaxation. There is no significant difference at short-term, long term survival rates and the neurological outcomes between manual traditional CPR and LUCAS in the randomized controlled studies.[20,21] There are another machines that work with similar mechanism. However there is no significant success on survival rates, discharge from hospital rate and good neurological outcomes in the studies which using these devices.[22,23] Three comprehensive randomized controlled trials show us the usage of LUCAS in cardiac arrests occurred in hospital had no significant effect on ROSC and also the usage of LUCAS may harm the patient. Also by taking the hospital discharge rates into consideration, it is found to be harmful when compared to traditional manual CPR.[24]

In 2015 AHA guidelines, the routine usage of these devices are not suggested as there is insufficient evidence. It is

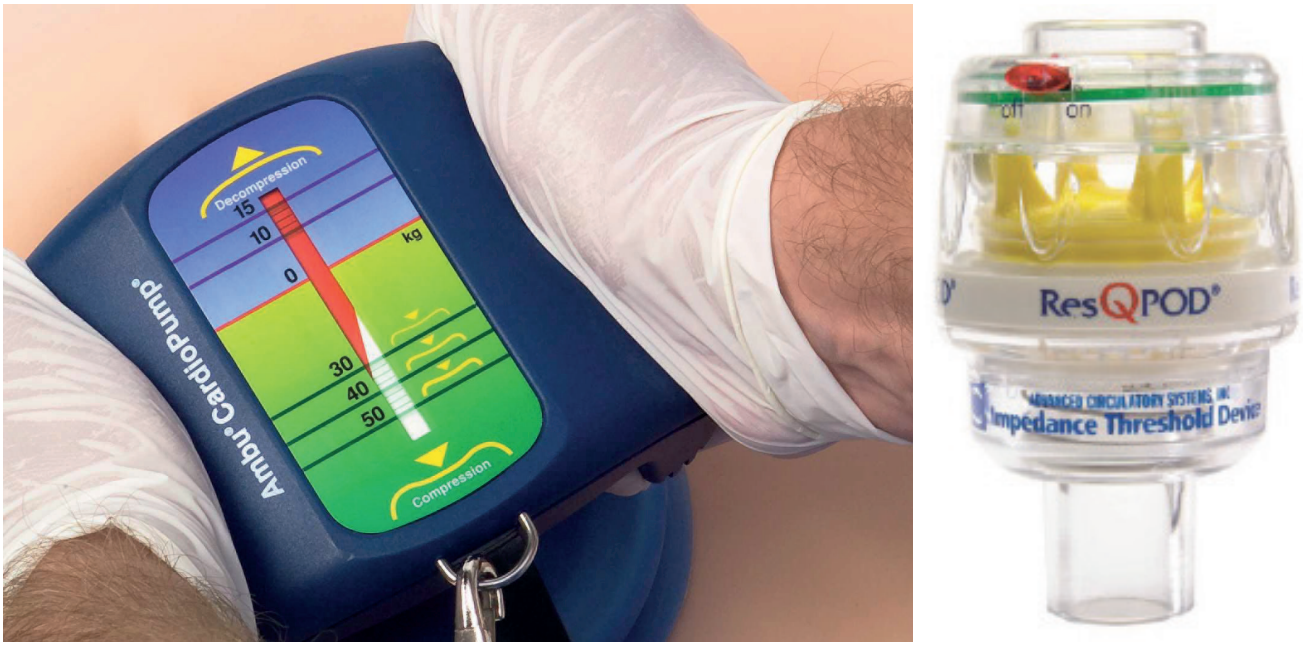

Figure 1. The compression and decompression process made by Cardiopump. (CardioPump ACD-CPR Device and ITD; ADVANCED CIRCULATORY SYSTEMS, INC. ; USA)

only suggested to be used when there is proper educated personnel (Class IIb, LOE B-R). Furthermore, the usage of mechanical chest compression devices with piston mechanism can be considered in situations where good quality CPR is not possible such as lengthened CPR, situations involving few rescuers, hypothermic cardiac arrest, ambulances on the move, during angiography and during preparations for extracorporeal CPR; but the chest compressions should not be interrupted during the placement of these devices. [10]

Figure 2. The Lund University Cardiac Assist System (LUCAS; Jolife, Lund, Sweden; distributed in the United States by Medtronic, Minneapolis, Minnesota, USA)

Load-Distributing Band Devices (LDB)

It is a mechanical chest compression device that is fixed on the backboard and works by surrounding the patient's chest either electronically or pneumatically. When the device was first entered usage, it was promoted as a very promising method. In a study conducted by Hock Ong et al., chest compressions done by LDB and traditional manual compressions were compared among 1011 in-hospital cardiac arrest cases. As a result they concluded similar results in the return of spontaneous circulation, but, the rates of hospital discharge and good neurological outcome results were found to be better in patients who received chest compressions via LDB.[25] However, in other clinical studies, in regards of 30-day survival rates and good neurological

Figure 3. AutoPulse Resuscitation System. AutoPulse and ZOLL are registered trademarks of ZOLL Medical Corporation in the United States.

outcomes, LDB was found to be inferior when compared to traditional manual CPR.[26-31] In 3 vast randomized controlled studies performed on in-hospital cardiac arrest cases, it is found that the usage of LDB does not provide a significant effect on the return of spontaneous circulation and may even cause harm. Also by taking the hospital discharge rates into consideration, it is found to be harmful when compared to traditional manual CPR.[24]

In 2015 AHA guidelines, the routine usage of these devices are not suggested as there is insufficient evidence. It is only suggested to be used when there is proper educated personnel (Class IIb, LOE B-R). Furthermore, the usage of mechanical chest compression devices with piston mechanism can be considered in situations where good quality CPR is not possible such as lengthened CPR, situations involving few rescuers, hypothermic cardiac arrest, ambulances on the move, during angiography and during preparations for extracorporeal CPR; but the chest compressions should not be interrupted during the placement of these devices.[10]

Conclusion

A recent extensive study on this subject is a meta-analysis published by Brooks SC et al. in 2014. This meta-analysis highlighted that there is not sufficient evidence for the mechanical chest compression devices to replace manual traditional chest compressions in cases of in-hospital cardiac arrest. Moreover, it is not proved to be superior to manual

CPR in aspects of return of spontaneous circulation, hospital discharge rates and good neurological outcomes.[32] Also in 2015 AHA guidelines, the usage of mechanical chest compression devices instead of traditional CPR methods is not suggested.[10] As a result, by considering all the data published in the recent years, in in-hospital cardiac arrest cases the mechanical chest compression devices should not be preferred over manual chest compressions.

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