American Journal of Emergency Medicine 34 (2016) 57–62

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Original Contribution

Comparison of chest compression interruption times across 2 automated devices: a randomized, crossover simulation study☆,☆☆,★

Jamie L. Estock, MA [a,*], Holly K. Curinga, MSN [b], Airan Li, MS [a], Lorin B. Grieve, PharmD [c], Christopher R. Brackney, DO [b]

[a] Center for Medical Product End-user Testing, VA Pittsburgh Healthcare System, Pittsburgh, PA
[b] Critical Care Service, VA Pittsburgh Healthcare System, Pittsburgh, PA
[c] Education Department, VA Pittsburgh Healthcare System, Pittsburgh, PA

ARTICLE INFO

Article history:
Received 13 August 2015
Accepted 14 September 2015

ABSTRACT

Objective: The goal of this study was to compare chest compression interruption times required to apply, adjust, and remove 2 different automated chest compression (ACC) devices using the same evaluation protocol.
Methods: Twenty-nine registered nurses and respiratory therapists used 2 ACC devices in separate resuscitation scenarios involving a patient manikin simulating a 45-year-old man in cardiac arrest in his intensive care unit room. Device presentation was randomized, with half of the participants using LUCAS 2 in the first scenario and the other half using AutoPulse in the first scenario.
Results: The mean chest compression interruption time to *apply* the ACC device to the patient was significantly shorter for AutoPulse (mean [M] = 31.6 ± 8.44) than for LUCAS 2 (M = 39.1 ± 11.20; $t(28) = 3.65$, $P = .001$). The mean chest compression interruption time to *remove* the ACC device from the patient and resume manual compressions was also significantly shorter for AutoPulse (M = 6.5 ± 3.65) than for LUCAS 2 (M = 10.1 ± 3.97; $t(26) = 3.36$, $P = .002$). There was no difference in the mean chest compression interruption time to *adjust* the position of the ACC device on the patient between AutoPulse (M = 14.3 ± 5.24) and LUCAS 2 (M = 12.5 ± 3.89; $t(23) = -1.45$, $P = .162$).
Conclusions: The results of this study trended in favor of AutoPulse. However, the interruption in chest compression to apply either device to the patient was notably longer than the maximum interruption time recommended by the American Heart Association.

Published by Elsevier Inc.

1. Introduction

Automated chest compression (ACC) devices, sometimes referred to as mechanical chest compression devices or cardiac resuscitators, were developed as an alternative way to maintain continuous high-quality chest compressions during the resuscitation process [1]. Specifically, ACC devices were developed to eliminate the decline in quality of circulation resulting from rescuer fatigue during prolonged manual compressions and to decrease the number of injuries rescuers sustain while delivering manual compressions. The 2 most commonly investigated ACC devices are LUCAS Chest Compression System (Physio-Control/Jolife AB, Lund, Sweden) and AutoPulse Resuscitation System (ZOLL Circulation, Sunnyvale, CA). Several studies have compared the clinical outcomes of patients treated with one of these ACC devices vs patients treated with manual compressions, such as the return of spontaneous circulation, survival to hospital admission, and survival to hospital discharge [2–14]. Most of these studies focused on evaluating the effectiveness of ACC devices during out-of-hospital resuscitation [2–13]. One study compared the effectiveness of ACC devices vs manual compressions during in-hospital resuscitation [14]. This study only compared the 2 treatment methods after 10 minutes of failed advanced life support interventions, making it difficult to determine the clinical effectiveness of ACC devices for the immediate treatment of in-hospital cardiac arrest. Furthermore, none of these clinical outcome studies measured the primary use-related hazard associated with ACC devices.

A use-related hazard is a potential source of patient harm caused specifically by how a medical device is used [15]. With ACC devices, the most common use-related hazards are the interruptions in chest compressions that occur during the application, position adjustment, and intentional removal of these devices for resumption of manual compressions. These interruptions are sometimes referred to as “no-flow time” or “hands-off time.” Longer interruptions in chest compressions

☆ Source of Funding: The execution of this work was supported by a Medical Education and Patient Safety grant through the Veterans Research Foundation at VA Pittsburgh Healthcare System, Pittsburgh, PA. The sponsor of this research had no involvement in the study design; in the collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit this article for publication.
☆☆ Disclaimer: The material is the result of work supported with resources and the use of facilities at VAPHS. The views expressed in this article are those of the authors and do not represent the official views of the Department of Veterans Affairs or the United States Government.
★ Conflicts of interest: The authors have no conflicts of interest relevant to this work.
* Corresponding author. VA Pittsburgh Healthcare System, University Drive C Research Building #30, G-39, Pittsburgh, PA 15240. Tel.: +1 412 360 2249; fax: +1 412 360 2492.
E-mail address: jamie.estock@va.gov (J.L. Estock).

http://dx.doi.org/10.1016/j.ajem.2015.09.011
0735-6757/Published by Elsevier Inc.

during the resuscitation process are associated with reduced survival rate postcardiac event as well as an increase in potential brain damage should the patient survive [16–18]. Prior studies have measured the interruptions in chest compression that occurred when using a single ACC device, but the differences in evaluation protocols and metrics used in these single-device studies make it difficult to compare interruption times across different ACC devices [18–24]. Furthermore, these studies are limited in that they only measured the aggregate chest compression interruption time over the entire resuscitation event or the interruption time to apply the ACC device to the patient. Interruptions in chest compression can also occur when a rescuer readjusts the position of the device on the patient. Position adjustments may be required to assure adequate compressions when the ACC device migrates out of position during operation. In addition, interruption in chest compression can occur when the device is removed from the patient to resume manual compressions. Such removal may be required due to device malfunction or inadvertent application to a patient who exceeds the size limits of the device. To our knowledge, there are no published data on the length of chest compression interruptions that occur when a rescuer needs to adjusts the position of an ACC device on a patient or remove an ACC device from a patient's body to resume manual compressions.

The goal of our study was to compare chest compression interruption times required to apply, adjust, and remove 2 different ACC devices using the same evaluation protocol. We also sought to identify potential causes of any extended interruption times by collecting user feedback. With this information, we hoped to inform a decision about the purchase of an ACC device to assist medical emergency response teams in the immediate treatment for patients who experience in-hospital cardiac arrest.

2. Methods

2.1. Design

This study used a randomized, crossover design where each participant used both ACC devices.

2.2. Setting

The study took place at Veterans Affairs Pittsburgh Healthcare System (VAPHS), a large academic medical center affiliated with the US Department of Veterans Affairs. Our evaluation took place in the VAPHS Clinical Simulation Center's mock intensive care unit (ICU) suite. The suite is embedded into an operational ICU at VAPHS and contains all of the same equipment and supplies found in an operational ICU room. We used the Advanced Life Support Simulator (Laerdal, Gatesville, TX) to mimic a patient in cardiac arrest. This study was determined to be "Exempt" by the institutional review board at VAPHS.

2.3. Participants

Eligible participants included the 165 doctors, nurses, and respiratory therapists on the multidisciplinary VAPHS medical emergency response team. This team is available 24/7 to evaluate, stabilize, and triage critically ill patients throughout the VAPHS campus. No members of the VAPHS medical emergency response team were excluded from participating in the study. Twenty-nine participants were recruited by 3 of the investigators in person and by e-mail during the month of August 2014, with evaluation sessions occurring in September 2014. Of the 29 study participants, 23 were registered nurses and 6 were respiratory therapists. None of the participants had previous experience using either ACC device.

2.4. Devices

2.4.1. AutoPulse

AutoPulse is an automated, portable, battery-powered ACC device (Fig. 1). AutoPulse was designed to deliver the compression force over a broader surface area of the thoracic cavity than manual compressions [25]. The device consists of 3 primary components—a platform backboard, a single-use chest compression band (LifeBand), and a rechargeable battery.

2.4.2. LUCAS 2

LUCAS 2 is an electric-powered ACC device (Fig. 2). LUCAS 2 was designed to deliver uninterrupted compressions at a consistent rate and depth [26]. The device consists of 3 primary components—a backboard, a top portion that contains an electrically driven piston rod that acts on the patient's chest via a pressure pad that is surrounded by a single-use suction cup, and a rechargeable battery. LUCAS 2 can be powered either by battery alone or using a wall or car electrical outlet.

2.5. Measures

The primary outcomes measured in this evaluation were the chest compression interruption times to *apply*, *adjust*, and *remove* the ACC devices. The interruption time to apply the ACC device was measured from the last manual compression to the first automated compression after application of the device. If a participant resumed manual compressions at any point during application of the ACC device, we excluded that manual compression time from their interruption time to apply measurement. The interruption time to adjust the ACC device was measured from

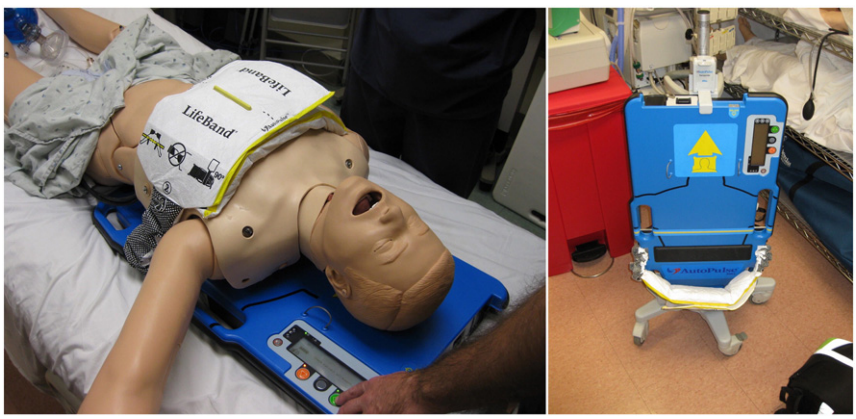

Fig. 1. Zoll's AutoPulse noninvasive cardiac support pump.