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Original Contribution

Does accelerometer feedback on high-quality chest compression improve survival rate? An in-hospital cardiac arrest simulation☆,☆☆,★

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ABSTRACT

Objective: We investigated whether visual feedback from an accelerometer device facilitated high-quality chest compressions during an in-hospital cardiac arrest simulation using a manikin.
Methods: Thirty health care providers participated in an in-hospital cardiac arrest simulation with 1 minute of continuous chest compressions. Chest compressions were performed on a manikin lying on a bed according to visual feedback from an accelerometer feedback device. The manikin and accelerometer recorded chest compression data simultaneously. The simulated patient was deemed to have survived when the chest compression data satisfied all of the preset high-quality chest compression criteria (depth ≥51 mm, rate >100 per minute, and ≥95% full recoil). Survival rates were calculated from the feedback device and manikin data.
Results: The survival rate according to the feedback device data was 80%; however, the manikin data indicated a significantly lower survival rate (46.7%; $P = .015$). The difference between the accelerometer and manikin survival rates was not significant for participants with a body mass index greater than or equal to 20 kg/m^2 (93.3 vs 73.3%, respectively; $P = .330$); however, the difference in survival rate was significant in participants with body mass index less than 20 kg/m^2 (66.7 vs 20.0%, respectively; $P = .025$).
Conclusions: The use of accelerometer feedback devices to facilitate high-quality chest compression may not be appropriate for lightweight rescuers because of the potential for compression depth overestimation.
Trial registration: Clinical Research Information Service (KCT0001449).

1. Introduction

The 2010 International Consensus on Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care Science With Treatment Recommendations outlined the conditions necessary for high-quality chest compression as a compression depth of at least 2 inches (5 cm) at a rate of at least 100 compressions per minute, full chest recoil, and minimal interruptions [1]. In particular, maintaining a compression depth of more than 5 cm during CPR is associated with higher survival rates in adult and pediatric cardiac arrest patients [2,3].

Therefore, a device that provides feedback on chest compression depth, chest wall recoil, and compression rates has been developed and shown to facilitate the performance of high-quality chest compression under simulated cardiac arrest conditions [4,5].

However, in 2009, Perkins et al [6] reported that accelerometer feedback devices could overestimate compression depth when compressions were performed on a soft surface. Such overestimation is likely to occur during in-hospital CPR because most cardiac arrest patients are lying on a bed. Although Oh et al [7] reported in 2012 that a dual accelerometer could prevent overestimation of compression depth, the dual accelerometer technique is not currently used in clinical settings.

We used a manikin in an in-hospital cardiac arrest simulation to investigate whether visual feedback from an accelerometer device facilitated the performance of high-quality chest compressions.

2. Material and methods

2.1. Study design

A prospective, nonrandomized single trial was carried out, with continuous chest compressions performed during 1 minute after regular CPR education at our hospital (Fig. 1). The study was approved by the institutional review board of our hospital (approval number: SA2015-07).

2.2. Study setting and study population

A total of 30 health care providers who worked in the emergency department of a community hospital participated in the study.

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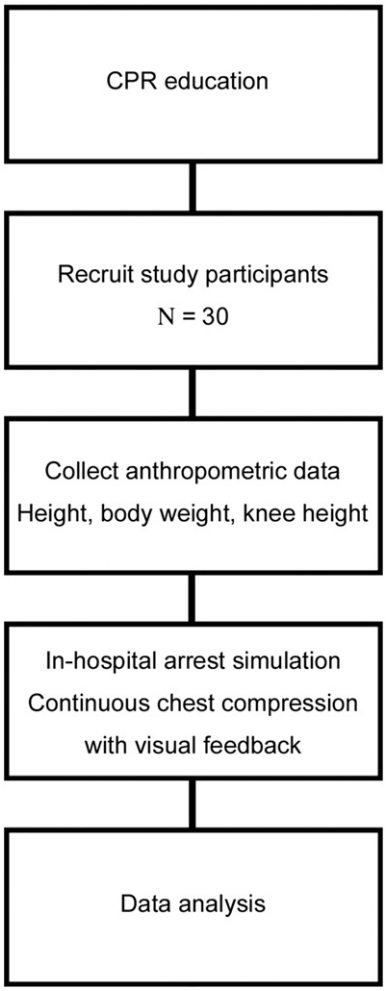

Fig. 1. Study flow diagram.

All participants were recruited voluntarily during regular CPR education and gave their verbal informed consent before the simulations.

In-hospital cardiac arrest simulations using a manikin were conducted in the simulation center of the hospital after CPR training. Chest compression data were collected during the simulation.

The sample size was calculated based on the mean compression depth (MCD) determined in a previous study (52.6 ± 6.7 mm) [8]. Given the SD of 6.7 mm, the expected MCD difference between the accelerometer device and manikin was postulated to be 10%, and the allowable difference was set at 5.26 mm. The 2-sided significance level was set at 0.05 with statistical power of 80%. The minimum number of participants was determined to be 13 using a Web-based program (sample size calculator: 1 sample mean) [9].

2.3. Study materials

The following devices were used during the simulation. The Stretcher Trolley–Paramount Model: KK-728E (Paramount Bed, Tokyo, Japan) was used for the in-hospital cardiac arrest simulation. We used a step stool to control for differences between bed height and rescuer knee height [10]. We measured the knee heights of 26 adults who did not participate in the study. The mean height of the rescuers' knees was 45.7 ± 3.0 cm (range, 39-52 cm); therefore, we set the difference between the bed and step stool height to 45 cm. The difference between bed and knee height could be adjusted within 10 cm using this method.

A Resusci Anne SkillReporter manikin (Laerdal Medical, Stavanger, Norway) was used as the simulated cardiac arrest patient. The Laerdal PC SkillReporting System (Laerdal Medical) was used to collect chest compression data from the manikin.

A CPRmeter (Laerdal Medical) was used to provide chest compression feedback. The CPRmeter provided visual feedback on compression depth, rate, and full recoil; and Q-CPR Review software version 3.1 (Laerdal Medical) was used to collect the data.

2.4. Study protocol

Cardiopulmonary resuscitation training, which did not include practice using a manikin, was conducted for 1 hour with a focus on the requirements for high-quality chest compression.

Previous investigations showed that chest compression quality was significantly lower when CPR was performed by lightweight rescuers than when performed by heavier rescuers; therefore, we recorded the participants' height and body weight before the simulation [11,12]. In addition, we recorded the participants' sex, age, and knee height (distance from the floor to the tibial tuberosity in the erect position) [8].

The in-hospital cardiac arrest simulation protocol was as follows. The manikin was placed on an emergency department bed in the supine position. Continuous chest compressions were performed according to the visual feedback provided by the accelerometer for 1 minute without ventilation assuming that an advanced airway was in place.

The participants practiced CPR for 1 minute before the simulation to familiarize themselves with the visual feedback provided by the accelerometer during chest compressions. The investigator supervising data collection used a stopwatch to accurately instruct the participants when to start and stop chest compressions. The practice was limited to 1 minute because rescuer fatigue and muscle strength affect the quality of chest compression [11-13].

The bed-to-step stool height was adjusted by measuring the height of the step stool (x cm), and the height of the bed (distance from the floor to the upper surface of the mattress) was then adjusted to (x + 45) cm. The same step stool and bed were used for all simulations and were fixed at the same height. The mattress used was provided by the bed manufacturer.

According to the 2010 International Consensus on CPR, there is insufficient evidence to argue for or against the use of backboards during CPR [1]. Therefore, we did not use a backboard in our simulations. The chest compression data were collected simultaneously by the accelerometer feedback device and manikin.

2.5. Outcome variables

The simulated patient was deemed to have survived when the chest compression data collected during the simulation satisfied all of the preset high-quality chest compression criteria. Conversely, the patient was considered to have died when not all of the criteria were met. Our criteria were based on the recommendations of the 2010 International Consensus on CPR for high-quality chest compressions and included MCD greater than or equal to 51 mm, mean compression rate (MCR) greater than or equal to 100 compressions per minute, and greater than or equal to 95% full chest recoil [1]. The "minimizing interruptions" recommendation was excluded because chest compression was continuous in our simulation. The acceptable percentage of compressions with full chest recoil was at the investigator's discretion because the recommended proportion was not stated in the 2010 International Consensus.

Survival rates were calculated from both the feedback device and manikin chest compression data. Survival rate was the primary outcome variable. The secondary outcome variables were the 5 chest compression indices common to the feedback device and the manikin: MCD (millimeters), MCR (counts per minute), adequate rate (percent), adequate depth (percent), and complete release (percent).

As chest compressions performed by lightweight rescuers are shallower than those performed by heavier rescuers, we assessed the outcome variables according to the participants' body mass index