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Can rescuers accurately deliver subtle changes to chest compression depth if recommended by future guidelines?

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ABSTRACT

Background: A recent study reported that a compression depth of 4.56 cm optimised survival following cardiac arrest, which is at variance with the current guidelines of 5.0–6.0 cm. A reduction in recommended compression depth is only likely to improve survival if healthcare professionals can accurately deliver a relatively small change in target depth. This study aimed to determine if healthcare professionals could accurately judge their delivered compression depth by 0.5 cm increments.
Method: This randomised interventional trial asked BLS-trained healthcare professionals to complete two minutes of continuous chest compressions on an adult manikin, randomised (without any feedback device), to compress to one of three target depth ranges of 4.0–5.0 cm, 4.5–5.5 cm or 5.0–6.0 cm, at the recommended rate of 100–120 compressions min^{-1}. Basic demographic data, compression rate, and compression depth were recorded.
Results: One hundred and one participants were recruited, of whom one withdrew. Median depths of 3.66 cm (IQR: 3.37–4.16 cm), 4.13 cm (IQR: 3.65–4.36 cm) and 4.76 cm (IQR: 4.16–5.24 cm) were found for the target depths of 4.0–5.0 cm (n = 30), 4.5–5.5 cm (n = 35) and 5.0–6.0 cm (n = 35) respectively ($P < 0.001$). Overall, 18 participants successfully compressed to their target depth.
Conclusions: Rescuers are able to judge 0.5 cm differences in compression depth with precision, but remain unable to accurately judge overall target depth. Reducing the current recommended compression depth to 4.56 cm is likely to result in delivered compressions significantly below the optimal depth.

Introduction

Since the birth of formal resuscitation techniques for victims of cardiac arrest, external chest compressions have formed a key intervention. Following recommendations published in 1960 by Kouwenhoven *et al*, to '*compress the chest once per second*' using the two-handed straight arm technique that we are still familiar with today [1], chest compressions have been a feature ever since in the first widely disseminated CPR guidelines in 1966 [2]. Chest compressions are an early link in the chain of survival and when delivered at the optimal rate and depth, improve both short and long-term survival from cardiac arrest [2–4]. Recommendations for the optimal compression depth have evolved over the past five decades, reflecting advances in clinical and experimental evidence, with iterations of resuscitation guidelines being disseminated as new evidence becomes available. A review of the scientific evidence relating to chest compression depth undertaken for the 2010 ILCOR (International Liaison Committee on Resuscitation) process concluded that the success of defibrillation and return of spontaneous circulation was improved with a compression depth of 5.0 cm (2 inches) or more [5]. Guidelines were subsequently amended to recommend a compression depth of at least 5.0 cm (but not exceeding 6.0 cm); [6] recommendations that were essentially unchanged in the 2015 guidelines update [7,8].

Although the 2015 guidelines continued to recommend 5.0–6.0 cm as the optimal chest compression depth [9–11], a paper evaluated for the 2015 ILCOR evidence review process concluded that a compression depth of 4.56 cm optimised survival following cardiac arrest [3]. During the ILCOR 2015 guidelines process, this new evidence was discussed in relation to whether the existing chest compression depth of 5–6 cm should be changed, as recommended by the authors. Consideration was given to recommending a change to 4.5–5.5 cm or perhaps 4.0–5.0 cm. If the optimal depth

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was to be reduced by 0.5 cm or 1.0 cm respectively, one concern was whether those delivering chest compressions would be able to judge such small differences. A decision was made to remain with the existing recommendations, but the optimal window for chest compression depth is likely to be revisited with forthcoming ILCOR evidence reviews. The ability to compress within the recommended target window has already been shown to be poor, regardless of target depth [16–18]. This suggests that the ability of rescuers to further estimate small changes in the compression depth if the guidelines were to make subtle adjustments would be poor.

If future guidelines did make changes to compression depth, ILCOR would need to be assured that rescuers could achieve a resolution of as little as 0.5 cm to accurately deliver the revised depth. This study therefore aimed to determine if healthcare professionals could accurately judge their delivered compression depth by 0.5 cm increments.

Methods

Study design

This was a prospective, randomised, manikin-based interventional study of single-rescuer, compression-only CPR. The study was conducted at University Hospital Southampton NHS (National Health Service) Foundation Trust over a 5-month period from September 2016 to January 2017.

Participants

Eligible participants were NHS professionals (staff or students), who had successfully completed a hospital-accredited basic life support (BLS) course, including a practical CPR component in which participants were required to demonstrate their ability to compress to a correct rate and depth without feedback. Exclusion criteria included pregnancy, significant medical illness or injury that would impair delivery of chest compressions. Recruitment posters were placed around the hospital site and researchers liaised with senior hospital staff and resuscitation training officers to recruit participants. Participants included medical and nursing students, junior doctors, operating department practitioners, operating theatre and ward nurses, and doctors of all grades from anaesthesia, general medicine, intensive care and surgery.

Equipment

Chest compressions were performed on a standard adult manikin (Laerdal Resusci Anne Basic (Laerdal Medical Limited, Orpington U.K.)) fitted with a 45 kg compression spring. The manikin was placed on the floor to standardise surface compliance between locations.

Chest compression performance was measured using a monitor-defibrillator (X-series; ZOLL Medical, Chelmsford, MA) with an integral accelerometer-based chest compression sensor that measured chest compression fraction, depth, and rate. The accelerometer was integrated into self-adhesive defibrillator pads that were pre-placed in the recommended position on the manikin. The Zoll monitoring screen was not visible to participants and all audio-visual feedback was disabled, including the integrated manikin chest compression clicker. Data was downloaded to a USB flash drive after each compression sequence and stored on an external hard drive. ZOLL RescueNet^{TM} Code Review software was used to extract compression rate and depth from this data for each volunteer.

Study procedure

Ethics and research governance approval was granted by Southampton University Ethics and Research Governance system (No: 19575) & NHS Health Research Agency respectively. The study was registered with CinicalTrials.gov (NCT03230461).

All participants were invited to read a Participant Information Sheet prior to providing informed written consent. A short standardised script was read to participants to explain the study and introduce participants to the equipment. Participants were asked to carry out three sets of uninterrupted chest compressions at different target depths, lasting two minutes each. The three depth ranges were 4.0–5.0 cm, 4.5–5.5 cm and 5.0–6.0 cm. Participants were instructed to compress directly onto the chest compression sensor, placed at the center of the manikin's chest and compress to the 2015 guideline recommended rate of 100–120 compressions per minute. To minimise the effect of fatigue, a break of two minutes was given after each compression sequence.

The order in which participants compressed to a specific depth range was randomised using a random number generator (randomizer.org). Allocation was concealed through opaque sealed white envelopes, which were randomly reordered by a third party with no connection to the project. Only data from the first chest compression sequence from each participant was used for the purposes of this study.

Data collection

For each compression sequence, mean compression depth and rate over the two-minute period were recorded. Demographic information on participants was also collected using an anonymised questionnaire, including sex, weight, height, years qualified in their respective profession and last basic life support (BLS) training. Body mass index (BMI) was calculated from the data.

Sample size

A previous study of chest compression performance using a target depth of 4.0–5.0 cm demonstrated a mean compression depth of 3.79 cm and a standard deviation of 1.00 cm [16]. Using this data and comparing a difference of 0.5 cm in compression depth between groups, a power of 0.80 with α (type I error rate) set at 0.05 would require a total sample size of 63 CPR sequences to identify any significance between two groups.

Statistical analysis

Data was analysed with SPSS (v. 24). Standard descriptive summaries, appropriate for the underlying distribution of the variable were calculated. Kruskall-Wallis and Mann-Whitney *U* tests were used to compare target depth ranges with the recorded compression performance. Binary logistic regression models were used to determine any correlation between demographic data and compression performance.

Results

Demographic data

The data collection period ran from October to November 2016, during which 101 participants met the necessary inclusion criteria and consented to taking part. Of these, one participant was excluded from analysis due to illness prior to taking part in the practical data collection. Data from all remaining participants was included in the analysis (Fig. 1).