Original Contribution

Impact of a feedback device on chest compression quality during extended manikin CPR: a randomized crossover study☆,☆☆,★

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ABSTRACT

Purposes: Chest compressions require physical effort leading to increased fatigue and rapid degradation in the quality of cardiopulmonary resuscitation overtime. Despite harmful effect of interrupting chest compressions, current guidelines recommend that rescuers switch every 2 minutes. The impact on the quality of chest compressions during extended cardiopulmonary resuscitation has yet to be assessed.
Basic procedures: We conducted randomized crossover study on manikin (ResusciAnne; Laerdal). After randomization, 60 professional emergency rescuers performed 2×10 minutes of continuous chest compressions with and without a feedback device (CPRmeter). Efficient compression rate (primary outcome) was defined as the frequency target reached along with depth and leaning at the same time (recorded continuously).
Main findings: The 10-minute mean efficient compression rate was significantly better in the feedback group: 42% vs 21% ($P<$ .001). There was no significant difference between the first (43%) and the tenth minute (36%; $P=$ .068) with feedback. Conversely, a significant difference was evident from the second minute without feedback (35% initially vs 27%; $P<$ .001). The efficient compression rate difference with and without feedback was significant every minute, from the second minute onwards. CPRmeter feedback significantly improved chest compression depth from the first minute, leaning from the second minute and rate from the third minute.
Principal conclusions: A real-time feedback device delivers longer effective, steadier chest compressions over time. An extrapolation of these results from simulation may allow rescuer switches to be carried out beyond the currently recommended 2 minutes when a feedback device is used.

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1. Introduction

Cardiac arrest survival is determined by the efficient and prompt activation of the 4 links in the historical "survival chain": immediate alert, early cardiopulmonary resuscitation (CPR), early defibrillation,

and postresuscitation care. However, resuscitation success and neurologic outcome depend on the efficient and successive implementation of those actions. Chest compression (CC) quality is a major prerequisite for successful defibrillation [1,2]. Consequently, the latest resuscitation guidelines still emphasize the importance of CC quality in CPR [3]. Chest compression is an important physical effort leading to fatigue depending on the rescuer's characteristics (sex, weight, age, sport practice) [4–6]. Chest compression efficiency rapidly decreases with time of performance [4,7–10], before rescuers know it [4,9]. Thus, current guidelines recommend that rescuers switch every 2 minutes for CC [3]. An increase in CC interruptions and hand-off time adversely affect cardiac arrest survival and neurologic outcome [11]. Chest compression interruptions also hamper CPR performance [12]. Many causes of avoidable and unavoidable CC interruptions remain (ventilation, airway control, vascular access, rhythm analyses, predefibrillation and postdefibrillation intervals, etc) [13]. The need for CPR guidance has been highlighted to reduce "hands-off" time and increase CPR quality

[14,15]. Thus, real-time feedback devices have been developed. They improved CPR skill acquisition and retention in training situations [16]. They allowed good performance in CPR with untrained bystanders [17]. Real-time feedback devices have proved their ability to enhance CC quality but have yet to demonstrate an improvement in patients' outcomes [18]. Furthermore, the "hands-off" time in CPR is still an important issue. A reduction in CC interruptions is required in conjunction with greater safeguarding of CC quality.

We hypothesized that CPR guidance should delay fatigue effects on CPR quality. The objective of this study was to assess the impact of a real-time feedback device on CC quality during an extended CPR.

2. Materials and methods

This study was approved by the local Ethics Committee (*Comité pour la Protection des Personnes Nord-Ouest III*, Caen, France, committee reference: 2007-17-SC, Chairperson Ms C Gourio) on April 28, 2014, and has the following registration number: A14-D20-VOL.21. Each participant received verbal and written information about the study protocol before giving their written informed consent for participation, data acquisition, and analysis.

2.1. Study design

This was a randomized controlled crossover study. The allocation ratio was 1:1.

2.2. Participants

Participants were professional rescuers (physicians, nurses, and ambulance drivers) from the emergency ambulance service (Service d'Aide Médicale Urgente) of the University Hospital of Caen (Normandy, France), trained in CPR and regularly involved in cardiac arrest care. Medical contraindications to sustained effort were explored according to a set form. Experiments were carried out under the supervision of two emergency physicians. Exclusion criteria were participant refusal or medical contraindication to sustained effort. Participants completed written inform consent and medical contraindication forms including demographic data.

2.3. Materials used

Specific CPR manikins (Resusci Anne; Laerdal) were used for the study. The tested feedback device was a CPRmeter provided by Laerdal (Laerdal Medical, Stavanger, Norway). The CPRmeter characteristics and functionalities have been previously described [17]. Target values are predefined by the manufacturer (Laerdal) according to 2010 guidelines. Feedback on CC provided by CPRmeter is only visual—there is no sound indication.

2.4. Intervention

In the first phase, participants were randomly assigned to one of the following experimental groups: guided group (group G) with feedback information provided by the CPRmeter device and blinded group (group B) using the CPRmeter device with the screen masked by an opaque adhesive. The second phase was in crossover with the first one. At least 4 hours passed between the 2 phases or any effort to avoid the fatigue effect (Fig. 1). Before performing CC, participants received a standardized waived reminder on CC guidelines and a brief standardized waived (30 seconds) and written description of the use and information provided by the CPRmeter device. They were then asked to perform 2 × 10 minutes of continuous CC only (without breathing assistance) (with and without guidance) on manikins lying down on a hard floor. The trial was performed in a quiet, isolated, designated room without any timer to avoid synchronization or external influence.

A start and stop signal was given, and no other indication or external assistance was provided. Participants could stop 10 minutes of continuous CC at any time for any reason. If the session was terminated before the 10 minutes had elapsed, then the session was over.

2.5. Data collection

Demographic data (sex, age, weight, size, medical history, treatment, sports practice, and professional experience in CPR) were collected from the general and medical information form. Heart rate, blood pressure, and Spo_2 were recorded before exertion and each minute during the 5-minute recovery period. For each 10-minute CC period, participants were asked to note the time at which they felt that CC quality was impaired by fatigue. Subjective fatigue was assessed secondarily according to the Borg scale [19].

Chest compression data were recorded using the CPRmeter device on a memory microSD card (1 Go) and extracted via dedicated software (Q-CPR review 3.1.0; Laerdal Medical AS, Stavanger, Norway) provided by the manufacturer. The available data concerning CC were rate, depth, recoil/release, and force applied. Data were exported to Microsoft Excel 2010 (version 14.0.6129.5000) and then to statistics software for statistical analysis (MedCalc 2.7.5 software; MedCalc software, Ostend, Belgium). Targets for each item of data were programmed in the CPRmeter device according to 2010 guidelines: CC rate between 100 and 120 per minute, CC depth between 50 and 60 mm; release weight less than 2500 g [20]. Any data outside those targets were considered incorrect.

2.6. Outcomes

The primary end point was the efficient CC rate defined by the combination at the same time of adequate CC frequency (100-120 per minute), adequate CC depth (between 50 and 60 mm), and an adequate CC release force (weight, <2500 g).

Secondary end points comprised average CC frequency, percentage of adequate CC frequency (100-120 per minute), average CC depth, percentage of adequate CC depth (between 50 and 60 mm), average CC peak force exerted, average CC release weight exerted, percentage of adequate CC release force (<2500 g), time after an efficient CC decrease of 30%, subjective fatigue scored on the Borg scale, time after which participants noted impaired CC quality, and participant's heart rate for 5 minutes at the end of the CC session.

2.7. Randomization

The allocation process involved the randomization of blocks of 4 participants. Investigators were not aware of the size of the blocks. The randomization process was stratified according to the groups (guide or blind) in the first phase.

2.8. Statistical methods

The sample size was based on a comparison of the primary end point (rate of efficient CC) for both groups: group G guided with feedback and group B blinded with feedback. With a β risk of 5%, an α risk of 5%, and group B displaying an efficient CC rate of 40%, our hypothesis was the superiority of group G over group B with an absolute difference of 15, based on the assumption that the SD of the difference in response variables was 3. We, therefore, planned to include 56 participants in this 2-way crossover design study. Considering the possibility of data loss, we enrolled 60 participants in this 2-way crossover design study.

The baseline characteristics of the study participants were described as percentages or median and range. Most of the collected data reporting chest compression quality was quantitative and was expressed as mean ± SD. The primary and secondary end points between both groups were compared according to the Student *t* test for