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Simulation and education

Rhythm analysis and charging during chest compressions reduces compression pause time☆

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ABSTRACT

Purpose: Prolonged chest compression interruptions immediately preceding and following a defibrillation shock reduce shock success and survival after cardiac arrest. We tested the hypothesis that compression pauses would be shorter using an AED equipped with a new Analysis during Compressions with Fast Reconfirmation (ADC-FR) technology, which features automated rhythm analysis and charging during compressions with brief reconfirmation analysis during compression pause, compared with standard AED mode.

Methods: BLS-certified emergency medical technicians (EMTs) worked in pairs and performed two trials of simulated cardiac resuscitation with a chest compression sensing X Series defibrillator (ZOLL Medical). Each pair was randomized to perform a trial of eight 2-min compression intervals (randomly assigned to receive four shockable and four non-shockable rhythms) with the defibrillator in standard AED mode and another trial in ADC-FR mode. Subjects were advised to follow defibrillator prompts, defibrillate if "shock advised," and switch compressors every two intervals. Compression quality data were reviewed using RescueNet Code Review (ZOLL Medical) and analyzed using paired *t*-tests.

Results: Thirty-two EMT-basic prehospital providers (59% male; median 25 years age [IQR 22–27]) participated in the study. End of interval compression interruptions were significantly reduced with ADC-FR vs. AED mode ($p < 0.001$). For shockable rhythms, pre-shock pause was reduced significantly with ADC-FR compared with AED use (7.35 ± 0.16 s vs. 12.0 ± 0.22 s, $p < 0.001$) whereas post-shock pause was similar (2.08 ± 0.14 s vs. 1.77 ± 0.14 s, $p = 0.1$).

Conclusion: Chest compression interruptions associated with rhythm analysis and charging are reduced with use of a novel defibrillator technology, ADC-FR, which features automated rhythm analysis and charging during compressions.

1. Introduction

External chest compressions are recognized as an essential component of resuscitation for patients in cardiac arrest.[1] Interruptions in external chest compressions have been shown to reduce survival and neurologic outcome from cardiac arrest.[2,3] Prolonged chest compression interruptions associated with automated rhythm analysis by an automatic external defibrillator (AED) immediately preceding and following a defibrillation shock have been shown to reduce shock success as well as survival after cardiac arrest.[4–7]

External chest compressions induce significant artifact into cardiac monitor waveforms, and frequently prevent interpretation of underlying cardiac rhythms (Fig. 1). For this reason it is standard practice for health professionals and rescuers to pause chest compressions after each 2-min chest compression cycle to allow an AED to perform cardiac rhythm analysis and to determine if a shockable rhythm is present.[8] Pauses for cardiac rhythm analysis can range from 8 to 26 s for standard AEDs. If a shockable rhythm – ventricular tachycardia or ventricular fibrillation – is present, the capacitor of the AED must then be charged so that a defibrillation shock can be delivered. The long pauses created by this sequential process can decrease the likelihood of shock success and survival.[5–7] Methods to reduce chest compression pauses have included performing chest compressions during AED charging and

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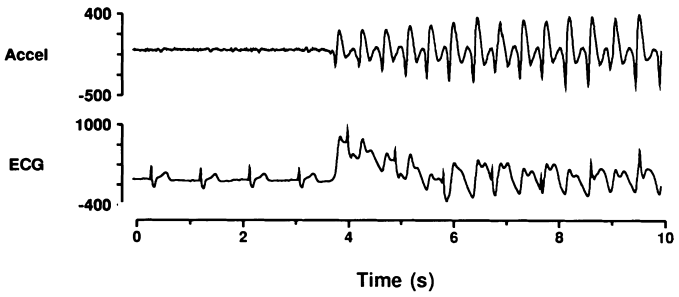

Fig. 1. Chest compressions measured by an accelerometer (upper panel) introduce artifact into the cardiac waveform (lower panel).

using AEDs that pre-charge during the 2-min chest compression cycles.

A new technology has been developed to reduce chest compression pauses during AED cardiac rhythm analysis and charging. This technology, known as Analysis during Compressions with Fast Reconfirmation (ADC-FR), combines automated rhythm analysis and charging during chest compressions with a brief reconfirmation analysis during compression pause. Low-pass subtraction filtering is used to filter chest compression artifact out of the cardiac rhythm signal in order to reveal the patient's underlying rhythm. A previously evaluated advanced cardiac algorithm is applied to the filtered rhythm to determine whether or not the patient's rhythm requires defibrillation.[9] The defibrillator capacitor is charged prior to the end of the chest compression cycle. Immediately upon cessation of compressions at the end of a compression cycle, the new technology performs a fast reconfirmation of the cardiac rhythm (Fig. 2). If a shockable rhythm is confirmed, the shock light is illuminated and the patient can be immediately defibrillated. Because the rescuer will only need to pause chest compressions long enough for the brief automated reconfirmation analysis and to deliver the shock, the interruption of chest compressions is minimized between the end of the chest compression interval and delivery of the electrical shock.

In addition, this technology should also reduce the pauses in chest compressions after a standard 2-min compression cycle in non-shockable rhythms such as pulseless electrical activity or asystole (Fig. 3). The standard pause for rhythm analysis is again reduced and the AED will issue a "no shock advised" order and chest compressions can restart promptly for the next 2-min cycle.

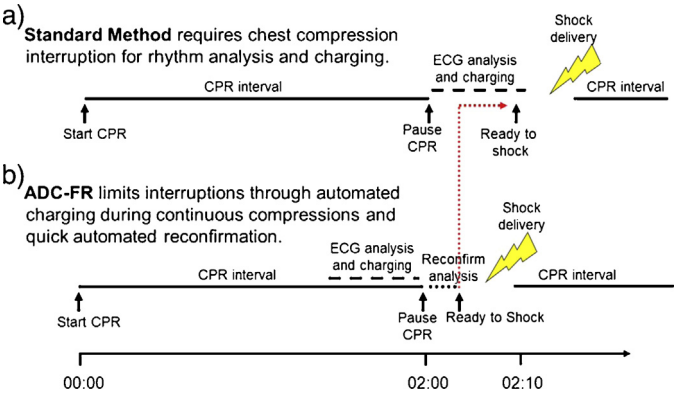

Fig. 2. Shockable rhythms: ADC-FR can reduce chest compression interruption when the cardiac rhythm is shockable. (a) The existing AED protocol requires interruption of CPR compressions (bold line) for ECG rhythm analysis and defibrillator charging (dash line); (b) with ADC-FR, cardiac rhythm analysis and charging occur during the chest compression interval and a brief reconfirmation analysis (dotted line) is conducted during the compression pause.

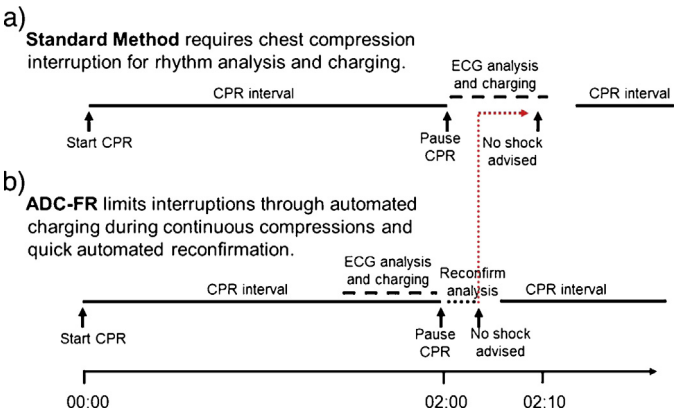

Fig. 3. Non-shockable rhythms: ADC-FR can reduce chest compression interruption when the cardiac rhythm is non-shockable. (a) The existing AED protocol requires interruption of CPR compressions (bold line) for ECG rhythm analysis (dashed line); (b) with ADC-FR, cardiac rhythm analysis occurs during the chest compression interval and a brief reconfirmation analysis (dotted line) is conducted during the compression pause.

The purpose of this investigation was to assess the performance of the ADC-FR technology in simulated resuscitations. Emergency medical technicians performed simulated resuscitations on a manikin using a defibrillator programmed in either ADC-FR or standard AED mode. We tested the hypothesis that external chest compression pauses at the end of compression intervals and, in particular, prior to a defibrillation shock, would be shorter using a defibrillator equipped with the new ADC-FR technology compared with the standard rhythm analysis technology.

2. Methods

The ADC-FR technology was evaluated in simulated cardiac arrest resuscitations using a prospective randomized crossover design.

2.1. Participants and setting

A convenience sample of basic life support (BLS) certified emergency medical technicians (EMTs) were asked to perform a simulated cardiac resuscitation on a manikin (Simulaids, Saugerties, NY). Study subjects were all actively working as EMTs for one ambulance service that employs approximately 150 EMTs. All subjects signed informed consent. Subjects were excluded if they were CPR instructors, if they had known health problems that could limit physical performance of CPR, or if pregnant. Prior approval of this investigation was obtained through the New England Institutional Review Board (NEIRB).

2.2. Data collection and measurement

Participants worked in pairs and performed two trials of simulated cardiac resuscitation while automated cardiac rhythm analyses were performed by an X Series defibrillator (ZOLL Medical Corporation, Chelmsford, MA). Each participant pair performed a trial of eight 2-min compression intervals with the defibrillator in standard AED mode and another trial in ADC-FR mode. The advisory protocols for the standard AED and ADC-FR modes were identical with regard to sequence and audio/visual prompts, but the time required for rhythm analysis was shorter for ADC-FR mode. Both modes complied with the 2010 AHA Guidelines.

The order of the AED and ADC-FR trials was randomized and subjects rested a minimum of 30 min between the trials. Subjects were blinded as to whether standard AED mode or ADC-FR was used