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Chest compression release velocity: Association with survival and favorable neurologic outcome after out-of-hospital cardiac arrest☆,☆☆

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ABSTRACT

Purpose: We evaluated the association between chest compression release velocity (CCRV) and outcomes after out-of-hospital cardiac arrest (OHCA).
Materials and methods: CPR quality was measured using a defibrillator with accelerometer-based technology (E Series, ZOLL Medical) during OHCA resuscitations by 2 EMS agencies in Arizona between 10/2008 and 06/2013. All non-EMS-witnessed adult (≥18 years) arrests of presumed cardiac etiology were included. The association between mean CCRV (assessed as an appropriate measure of central tendency) and both survival to hospital discharge and neurologic outcome (Cerebral Performance Category score = 1 or 2) was analyzed using multivariable logistic regression to control for known and potential confounders and multiple imputation to account for missing data.
Results: 981 OHCAs (median age 68 years, 65% male, 11% survival to discharge) were analyzed with 232 (24%) missing CPR quality data. All-rhythms survival varied significantly with CCRV [fast (≥400 mm/s) = 18/79 (23%); moderate (300–399.9 mm/s) = 50/416 (12%); slow (<300 mm/s) 17/255 (7%); $p < 0.001$], as did favorable neurologic outcome [fast = 14/79 (18%); moderate = 43/415 (10%); slow = 11/255 (4%); $p < 0.001$]. Fast CCRV was associated with increased survival compared to slow [adjusted odds ratio (aOR) 4.17 (95% CI: 1.61, 10.82) and moderate CCRV [aOR 3.08 (1.39, 6.83)]. Fast CCRV was also associated with improved favorable neurologic outcome compared to slow [4.51 (1.57, 12.98)]. There was a 5.2% increase in the adjusted odds of survival for each 10 mm/s increase in CCRV [aOR 1.052 (1.001, 1.105)].
Conclusion: CCRV was independently associated with improved survival and favorable neurologic outcome at hospital discharge after adult OHCA.

1. Introduction

Annually, EMS treats over 350,000 out-of-hospital cardiac arrests (OHCA) in the U.S.[1] Outcomes vary widely between communities with survival rates for ventricular fibrillation (VF) ranging from 3.3% to 45%.[2–4] The quality of CPR delivered, defined by chest compression (CC) rate, depth, fraction, and "recoil," is thought to impact outcomes and is believed to be one factor contributing to the large disparities in survival.[4–8] Both the European Resuscitation Council (ERC) and the American Heart Association (AHA) recommend complete chest wall recoil as a component of high-quality CPR.[9,10]

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While optimal CC rate, depth and fraction have been associated with improved outcomes from cardiac arrest,[5–7,11,12] there is a paucity of data describing the release phase of chest compressions. The AHA and ERC recommendations of complete chest recoil/no leaning are based on animal studies which have implicated complete chest wall recoil as an important factor in maximizing blood flow during CPR[13–15] and clinical data demonstrating that providers frequently do not allow complete recoil.[6,16–18] There are no data demonstrating an association between optimization of the release phase of chest compressions and clinical outcomes.

The purpose of this analysis was to assess whether CCRV, the maximal velocity of chest compression release in the posterior to anterior direction, is associated with improved survival to hospital discharge and a favorable neurologic outcome after adult OHCA.

2. Methods

2.1. Study setting

Data for this study were collected from 2 EMS agencies in Arizona. The Mesa Fire and Medical Department is a suburban-based agency that responds to 70,000 calls per year (population 439,000). There are 373 emergency medical technicians (EMTs) employed by the department, which deploys two EMT Basics (EMT-B) and two EMT Paramedics (EMT-P) as a typical crew. Guardian Medical Transport (GMT) responds to a suburban and rural area with approximately 14,000 annual 9-1-1 calls (population 80,000). GMT employs 80 EMTs and dispatches a crew of at least one EMT-P and EMT-B to emergency calls. Both EMS agencies participate in the Save Hearts in Arizona Registry and Education (SHARE) Program, a statewide cardiac resuscitation quality improvement program, and use minimally interrupted cardiac resuscitation (MICR) as their adult resuscitation protocol.[19,20]

2.2. Study design and population

We describe a prospective, before-after, observational cohort study of consecutive adult (aged ≥18 years) OHCA of presumed cardiac etiology between 10/2008 and 6/2013. Cases were excluded if prehospital resuscitation was not initiated, the patient had a do-not-resuscitate order, the arrest was witnessed by EMS, or if the cause of the arrest was presumed to be non-cardiac (known respiratory arrest, suicide, trauma, drowning, or drug overdose). The SHARE Program also tracks hospital data and if it becomes clear that the cause of the arrest was non-cardiac, the database is updated.

Baseline CPR quality and outcome data (10/2/08–2/27/10) were collected during Phase 1 (P1) before a dedicated educational initiative (described in detail previously)[5,21] and without the use of real-time audiovisual feedback (RTAVF) for CC quality. The educational intervention included 2 h of didactics and 2 h of psychomotor practice, termed "Scenario-Based Training" (SBT), which emphasizes a team approach to resuscitation and close compliance with the parameters of high-quality CPR.[9,22] Phase 2 (P2) began on 5/19/10 after the completion of training and the enabling of the monitor-defibrillator's RTAVF software (E-series, ZOLL Medical), with data collection ending 6/27/13. This technology has been described in detail previously and does not include feedback regarding CCRV.[21]

2.3. Data collection

CCRV was assessed via the accelerometer present in the defibrillators.[21] Recorded CC quality data included overall compression fraction, pre-shock pause, and minute-by-minute compression rate, depth, and release velocity data. CPR quality data were matched with patient first care reports which were collected as part of the SHARE Program. SHARE employs an Utstein-style database linked to hospital outcomes and has been previously described.[19]

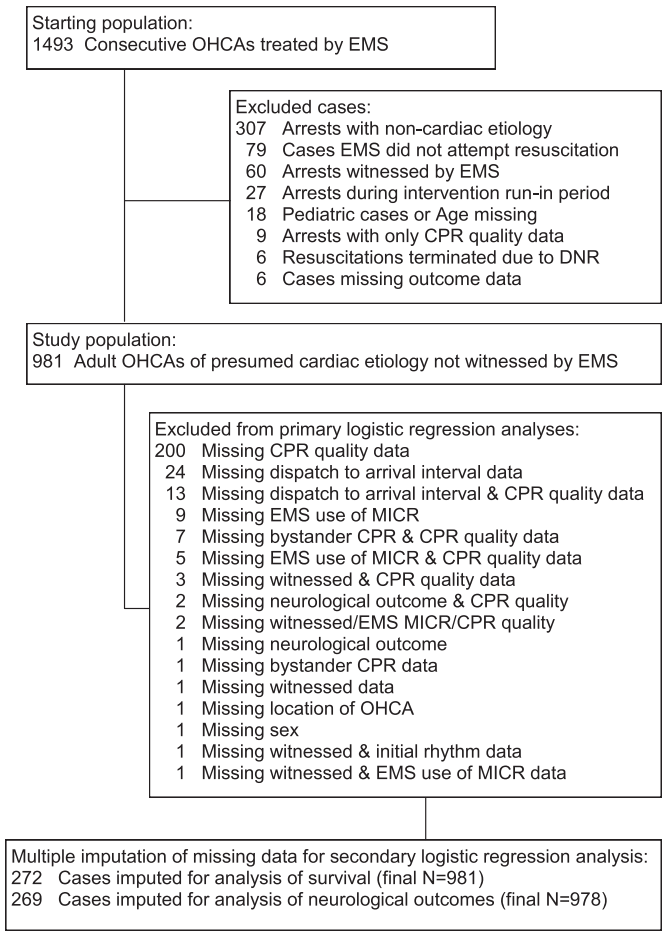

Fig. 1. Study population inclusion and exclusion flowchart.

As an Arizona Department of Health Services (ADHS)-sponsored public health initiative, Arizona's Attorney General has determined that the SHARE Program is exempt from the requirements of the Health Insurance Portability and Accountability Act (HIPAA) allowing linkage of EMS and hospital data, tracking of OHCA events, and evaluation of efforts to improve resuscitation care. By virtue of being a public health initiative, the ADHS Human Subjects Review Board and the University of Arizona Institutional Review Board have determined that neither the interventions nor their evaluation constitute Human Subjects Research and have approved the publication of de-identified data. The project is registered at clinical Trials.gov#NCT01999036.

2.4. Statistical analysis

The analytical approach is similar to Vadeboncoeur et al.[5] The primary outcomes for this study were survival to hospital discharge and survival with favorable neurologic outcome [Cerebral Performance Category (CPC) Score = 1 or 2]. CCRV was assessed as a categorical variable [fast (≥400 mm/s), moderate (300–399.9 mm/s), or slow (<300 mm/s)] as well as a continuous variable (mm/s).[23] Crude proportions were compared using Fisher's exact test. We analyzed the distribution of release velocities for chest compressions of individual OHCA cases to determine the appropriateness of using mean CCRV as a measure of CPR quality. Multivariable logistic regression was used to assess the