



Clinical paper

Rhythm profiles and survival after out-of-hospital ventricular fibrillation cardiac arrest



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ABSTRACT

Objective: Treatment protocols for cardiac arrest rely upon rhythm analyses performed at two-minute intervals, neglecting possible rhythm changes during the intervening period of CPR. Our objective was to describe rhythm profiles (patterns of rhythm transitions during two-minute CPR cycles) following attempted defibrillation and to assess their relationship to survival.

Methods: The study included out-of-hospital cardiac arrest cases presenting with ventricular fibrillation from 2011 to 2015. The rhythm sequence was annotated during two-minute CPR cycles after the first and second shocks of each case, and the rhythm profile of each sequence was classified. We calculated absolute survival differences among rhythm profiles with the same rhythm at the two-minute check.

Results: Of 569 rhythm sequences after the first shock, 46% included a rhythm transition. Overall survival was 47%, and survival proportion varied by rhythm at the two-minute check: ventricular fibrillation (46%), organized (58%) and asystole (20%). Survival was similar between profiles which ended with an organized rhythm at the two-minute check. Likewise, survival was similar between profiles with asystole at the two-minute check. However, in patients with ventricular fibrillation at the two-minute check, survival was twice as high in those with a transient organized rhythm (69%) compared to constant ventricular fibrillation (32%) or transient asystole (28%).

Conclusion: Rhythm transitions are common after attempted defibrillation. Among patients with ventricular fibrillation at the subsequent two-minute check, transient organized rhythm during the preceding two-minute CPR cycle was associated with favorable survival, suggesting distinct physiologies that could serve as the basis for different treatment strategies.

1 Introduction

Cardiopulmonary resuscitation (CPR) involves a coordinated set of actions critical to survival following out-of-hospital cardiac arrest. Current resuscitation guidelines highlight the importance of high-quality CPR, which is characterized by a chest compression rate of 100–120 per minute, depth of at least 2 inches, full chest recoil, and minimal interruptions [1–6]. However, compressions are routinely interrupted every two minutes for accurate rhythm diagnosis. These two-minute rhythm checks inform shock decisions, pulse checks, and medication decisions, as well as give prognostic information.

While rhythms are typically assessed and treated at successive two-

minute intervals, there is evidence that the underlying rhythm evolves during the intervening period of CPR, which we refer to as a two-minute CPR cycle [7–9]. Little is known about the distribution of these dynamic rhythm profiles (i.e., the patterns of rhythm transitions) or how these rhythm profiles might add prognostic information to that provided by the traditional, episodic two-minute rhythm checks. In this study, we identified rhythm profiles during the two-minute CPR cycles that followed the first and second shocks delivered to patients presenting with ventricular fibrillation and assessed the relationship between rhythm profile and survival.

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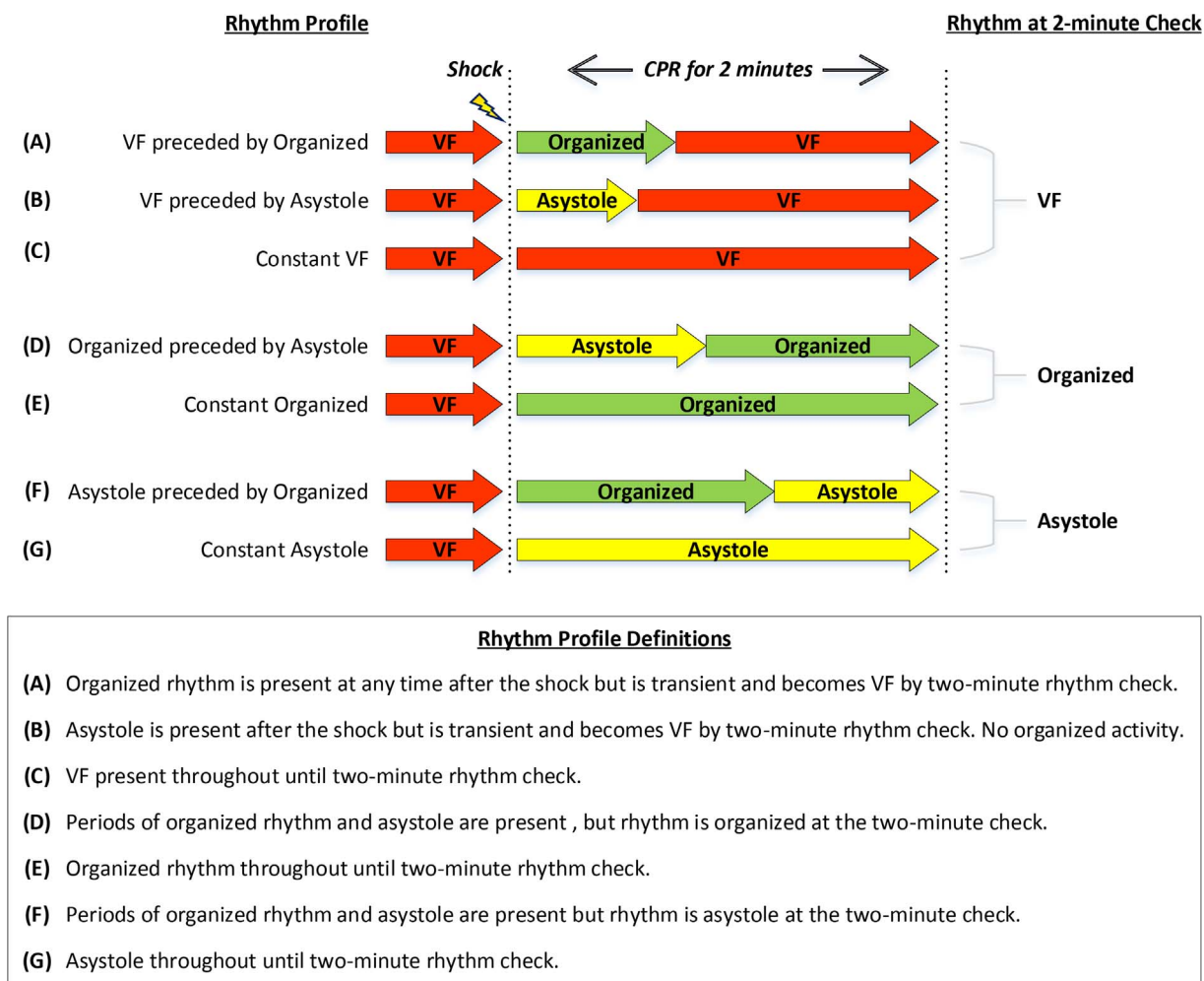


Fig. 1. Definitions of rhythm profiles during two-minute CPR cycles. This figure shows schematic examples of the seven rhythm profiles with brief descriptions. Ventricular fibrillation (VF) precedes each shock.

2 Methods

This study was approved by the Institutional Review Board for Human Subjects Research at the University of Washington and the Department of Public Health—Seattle and King County.

2.1 Study design, population, and setting

Our study population was adult cardiac arrest patients with an initial rhythm of ventricular fibrillation who were treated by a large metropolitan Emergency Medical Services system from 2011 to 2015. Because initial rhythm is a strong predictor of survival and could therefore confound the association between rhythm profile and survival, we restricted the cohort to those with an initial rhythm of ventricular fibrillation. Cases were included if the electronic defibrillator recording contained at least two minutes of ECG and transthoracic impedance data after the first shock; the transthoracic impedance data provided CPR performance information and were necessary for accurate rhythm interpretation. Cases were *a priori* excluded if a patient had do-not-resuscitate status, or a public access or law enforcement defibrillator delivered a shock prior to EMS arrival (thereby rendering the ECG data unavailable after the first delivered shock).

The EMS system of the study community consists of a two-tiered system activated by calling 9-1-1 and speaking with an emergency medical dispatcher. The first tier consists of fire-fighter-emergency medical technicians equipped with automated external defibrillators and trained in basic life support. The second tier consists of paramedics

trained in advanced life support. On average, the first tier arrives 5 min after dispatch and the second tier arrives 10 min after dispatch. The resuscitation strategy derives from the American Heart Association guidelines [3].

The EMS Division maintains an ongoing registry of every EMS-treated cardiac arrest according to the Utstein Guidelines [10,11]. Registry data include patient demographics, event circumstances, and care and clinical course from a range of sources, including dispatch audio transcripts, EMS reports, defibrillator recordings, hospital records, and death certificates. Defibrillator recordings include various types of data, such as ECG, transthoracic impedance, and accelerometer information, as well as the real-time audio recording in which the EMS providers describe the status and care of the patient. Specific defibrillators models employed in this study were the Philips Forerunner, Philips MRx, and Physio-Control Lifepak 12 and 15.

2.2 Annotation of rhythm sequences

We defined the rhythm sequence as the continuous rhythm time series throughout each case. Two investigators blinded to clinical outcome data annotated the rhythm sequence from the first shock of the resuscitation to the third shock (in order to include the two-minute CPR cycles after the first and second shocks) for a maximum of five minutes. Rhythm sequence annotation began after a shock as soon as the ECG returned to baseline. Possible rhythms were ventricular fibrillation, organized rhythms, asystole, and ventricular tachycardia. Standard rhythm definitions were employed, with the proviso that an extreme

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