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Clinical paper

Causes for the declining proportion of ventricular fibrillation in out-of-hospital cardiac arrest☆

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ABSTRACT

Aims: The reported proportion of ventricular fibrillation (VF) in out-of-hospital cardiac arrest (OHCA) has declined worldwide. VF decline may be caused by less VF at collapse and/or faster dissolution of VF into asystole. We aimed to determine the causes of VF decline by comparing VF proportions in relation to delay from emergency medical services (EMS) call to initial ECG (call-to-ECG delay), and VF dissolution rates between two study periods.

Methods: Data from the AmsteRdam REsuscitation STudies (ARREST), an ongoing OHCA registry in the Netherlands, were used. We studied cardiac OHCA in the study periods 1995–1997 ($n = 917$) and 2006–2012 ($n = 5695$). Cases with available ECG and information on call-to-ECG delay were included. We tested whether initial VF proportion and VF dissolution rates differed between both study periods using logistic regression.

Results: Despite a 15% VF decline between the periods, VF proportion around EMS call remained high in 2006–2012 (64%). The odds ratio (OR) for VF proportion in 2006–2012 vs. 1995–1997 was 0.52 (95%-CI 0.45–0.60, $P < 0.001$), with similar rates of VF dissolution in both periods ($P = 0.83$). VF decline was higher for unwitnessed collapse (OR 0.41, 95%-CI 0.28–0.58) and collapse at home (OR 0.50, 95%-CI 0.42–0.59), but not for categories of bystander CPR, age or sex.

Conclusion: VF proportion early after collapse remains high. VF decline is explained by the occurrence of less initial VF, rather than faster dissolving VF. An increase in unwitnessed OHCA and collapse at home contributes to the observed VF decline.

1. Introduction

Reported proportions of ventricular fibrillation (VF) in out-of-hospital cardiac arrest (OHCA) have declined worldwide[1–12], dropping from proportions as high as 70% to proportions as low as 24%.[6,7] Because VF is the most important predictor favoring survival of OHCA, it is important to understand the causes of this decline.[13] As time from collapse passes, VF will dissolve into asystole. This process may be slowed but not stopped by cardiopulmonary resuscitation (CPR).[14] Since there is often considerable delay between collapse and initial ECG recording, some patients who present in asystole may have actually collapsed due to VF. This results in an underestimation of the proportion of VF as the true cause of the collapse. The magnitude of this underestimation depends on the dissolution speed of VF into asystole.[15]

Several explanations have been proposed for the observed decline in the proportion of VF (Fig. 1). First, dissolution of VF into asystole may have accelerated over the years (Hypothesis 1), possibly due to increased use of β-adrenoreceptor blockers.[16,17] Second, the epidemiology of sudden cardiac arrest may have changed, and rhythms other than VF (asystole, pulseless electrical activity [PEA]) may have more often become the true cause of the collapse (Hypothesis 2).[18] We aimed to test both hypotheses. To do so, we compared the proportions of VF between two study periods (1995–1997 and 2006–2012), and the VF dissolution rates between both study periods.

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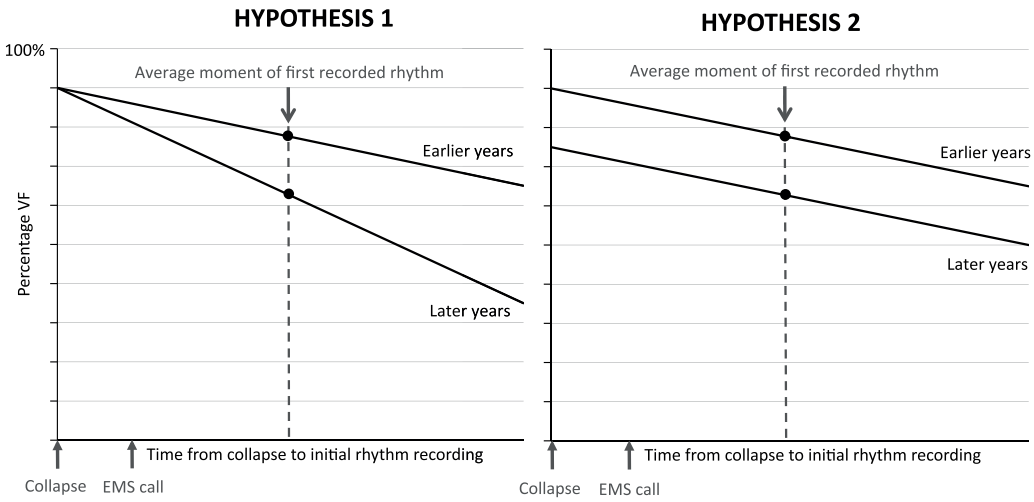

Fig. 1. Schematic representation of two competing hypotheses to explain the observed decline in VF. Hypothesis 1: over the years the proportion of VF causing the collapse has not changed but VF dissolves faster into low voltage VF and subsequent asystole. Hypothesis 2: at the onset of collapse, other causes than VF became more prominent in the later period, such as PEA (pulseless electrical activity) or primary asystole. The rate of dissolution has not changed over the years. When the initial rhythm is only recorded with a typical average delay (6–10 min after collapse), in both hypotheses the same overall proportion of VF is noted, but the changing cause of the collapse cannot be recognized. EMS denotes emergency medical services; VF ventricular fibrillation.

2. Methods

2.1. Data source

We compared data from an earlier study period (1995–1997) and a later study period (2006–2012) retrieved from the ARREST (AmsteRdam REsuscitation STudies) registry. ARREST is an ongoing prospective registry of all resuscitation attempts in the community. In the earlier study period, the study region was Greater Amsterdam, i.e. Amsterdam and surroundings (1.3 million inhabitants, 1030 km^2).[19] In the later study period, the study region was Greater Amsterdam along with the remaining parts of the province surrounding it (North-Holland province, 2.4 million inhabitants, 2671 km^2, both urban and rural communities). Characteristics of patients from both study regions were comparable (Supplemental Table 1).

In case of a medical emergency, people dial the national emergency number. When suspecting a cardiac arrest, the emergency medical services (EMS) dispatcher sends two ambulances of a single tier equipped with a manual defibrillator. Since 2000 automatic external defibrillators (AEDs) are increasingly available and the EMS dispatcher also sends first responders (policemen, fire fighters, local lay rescuers) with an AED.[20]

For all suspected OHCA calls, dispatch forms with time stamps of start of EMS call and EMS dispatch were collected. After each resuscitation attempt, paramedics routinely sent the continuous ECG recording from their manual defibrillators to the study center by modem or Internet. ECG data were stored and analyzed with dedicated software. Paramedics reported whether an AED was used before ambulance arrival. Study personnel collected the ECG recording from the AED. The clock times of the AED or manual defibrillator recordings were synchronized with the dispatch system clock to calculate the time delay between EMS call and initial ECG recording.

For all OHCA cases in our registry we assessed the initial rhythm from ECG recordings from AED or manual defibrillator. The initial rhythm was categorized as VF or non-VF. Baseline characteristics of OHCA patients were obtained from the dispatch center, first responders, paramedics and from the hospital.

The study complied with the Declaration of Helsinki. The Medical Ethics Review Board of the Academic Medical Center, Amsterdam, approved the study and gave a waiver for obtaining (written) informed consent.

2.2. Study population

We included patients in whom EMS personnel attempted resuscitation during OHCA between June 1, 1995 and August 1, 1997 (earlier period) or between January 1, 2006 and December 31, 2012 (later period). Patients with a clear non-cardiac cause of the arrest, ambulance witnessed OHCAs and patients without available ECG or unknown timestamps were excluded from the analysis.

2.3. Definitions

Because the moment of collapse was not recorded, the time of EMS call was taken as the reference. We defined the time delay between EMS call and time of initial rhythm on the ECG as 'call-to-ECG delay'. The attachment of an AED before the EMS call resulted in a 'negative' call-to-ECG delay. We considered rhythm assessment with a negative or less than 2 min call-to-ECG delay as 'early after collapse', We defined the decrease in proportion of VF between the earlier and the later study periods as 'VF decline', and the decrease in proportion of VF with increasing call-to-ECG delay as 'VF dissolution'.

2.4. Data analysis

The proportion of VF in relation to call-to-ECG delay in the earlier and later periods was analyzed in a logistic regression model with 'call-to-ECG delay' (minutes) as continuous variable and 'study period' (earlier or later period) as binary variable. The odds ratio (OR) for study period was the measure for VF decline between both study periods, and the OR for call-to-ECG delay the measure for decrease in proportion of VF for each minute call-to-ECG delay. The interaction between study period and call-to-ECG delay indicated differences in VF dissolution rate between study periods.

In addition to the main analysis, we performed sensitivity analyses on the results of the logistic regression analysis. As the call-to-ECG delay in unwitnessed cases is an unreliable estimate of total delay, we tested the results when excluding unwitnessed cases. As no AEDs were used in the earlier period and consequently