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Improving trend in ventricular fibrillation/pulseless ventricular tachycardia out-of-hospital cardiac arrest in Rochester, Minnesota: A 26-year observational study from 1991 to 2016☆

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ABSTRACT

Background: Mortality from out-of-hospital cardiac arrest (OHCA) is characterized by substantial regional variation. The Institute of Medicine (IOM) recently recommended enhancing the capabilities of EMS systems to improve outcome. In this study, we analyzed the trend in outcome from ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT) OHCA in Rochester, MN. Survival from these forms of arrest is commonly employed as a benchmark of Emergency Medical Services (EMS) system performance.
Methods: Using a population-based Utstein-style registry in Rochester, MN where a first responder early defibrillation system is utilized, we evaluated outcome from all EMS-treated VF/pVT arrests and the subgroup of bystander-witnessed VF/pVT from 1991 to 2016. Outcome measurement was neurologically intact survival to discharge, defined as Cerebral Performance Category (CPC) 1 or 2. We divided the 26-year study into three periods: 1991–1997, 1998–2008, and 2009–2016, based on initiation of the first responder system of police officers in 1991 and fire-rescue personnel in 1998, and the latter period for comparison with our previous report in 2009.
Results: We observed 355 all VF/pVT arrests and 292 bystander-witnessed VF/pVT arrests between 1991 and 2016. In 2009–2016, neurologically intact survival to discharge from overall VF/pVT and bystander-witnessed VF/pVT increased to 53.7% and 65.2%, respectively, compared with 39.5% and 43.4% in 1991–1997. Using multivariable analysis, survival significantly increased in 2009–2016 among all VF/pVT arrests (adjusted OR, 3.10; 95% CI, 1.54–6.40) and bystander-witnessed VF/pVT (adjusted OR, 4.28; 95% CI, 2.01–9.50), compared with those in 1991–1997.
Conclusions: We observed a significant improving secular trend in neurologically intact survival from VF/pVT cardiac arrests with a relatively high recent survival rate in this EMS System.

Introduction

Out-of-hospital cardiac arrest (OHCA) is a major public health problem, affecting over 350,000 people annually in the United States [1]. Although organizations such as American Heart Association (AHA) and International Liaison Committee on Resuscitation (ILCOR) have been making intensive efforts to improve survival from OHCA and prior studies showed improving trend in outcome, recent mortality is still high, with an 88.6% mortality rate among emergency-medical-services (EMS)-treated OHCA in the US in 2015 [1–6]. Additionally, there is substantial regional variation in survival from OHCA in North America, suggesting there is an opportunity to improve care via disseminating "best practices" to regions with lower survival [7–9].

A recent report from the Institute of Medicine (IOM) emphasized the importance of multifaceted interventions to improve survival, including recommendations to enhance the capabilities and performance of EMS systems [10,11]. The ILCOR Consensus Statement also recommended reporting of bystander-witnessed shockable rhythm (ventricular fibrillation/pulseless ventricular tachycardia

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[VF/pVT]) as a measure of EMS system performance [12]. In 2009, we reported a 46.3% rate of neurologically intact survival to hospital discharge in bystander-witnessed OHCA due to VF/pVT [13]. The objective of this current study was to assess the most recent trend in neurological outcome from all VF/pVT and bystander-witnessed VF/pVT in our city.

Methods

Study design and settings

This investigation was an analysis of an ongoing prospective, registry system of OHCA in accordance with Utstein-style data collection that included the entire population of Rochester, Minnesota. The materials and methods have been described in detail elsewhere [13–16]. Briefly, we developed an Early Defibrillation Program to provide support to the Advanced Life Support (ALS) Emergency Medical Services (EMS) paramedic response. Initially police officers were AED-equipped and subsequently fire-rescue personnel were added to the response. In November 1990, police officers were equipped with 12 AEDs along with basic life support (BLS) training and therefore all 12 squad cars in service at any time were AED equipped [13–16]. Similarly fire-rescue personnel were incorporated into the first responder system with 6 AEDs and BLS training in 1998 [13,14]. The first 6 AEDs were placed on 4 engines and 2 ladder trucks and therefore all 6 staffed emergency response vehicles were AED equipped. At that time of introduction of AEDs to the fire department, there were 4 fire stations for the 6 AED-equipped vehicles. Thus fire-rescue was functioning at this time as back-up for the police department. This arrangement enabled a first responder, whether a police officer or fire-rescue personnel, to arrive at the scene of all cardiac arrests. In 2016, new AEDs were obtained to replace existing AEDs, and police officers and fire-rescue personnel were equipped with 42 and 25 AEDs respectively to provide first-responder coverage. The annual budgets at the fire and police departments and anticipated expansion of geographic coverage area and population led to the increase in the number of AEDs. During the period of study, the population of the city increased progressively from 70,745 in 1990 to 112,225 in 2015, and the geographic coverage area increased from 30 square miles to 54.59 square miles [13,17]. This investigation was part of an Institutional Review Board-approved prospective observational outcome study of all patients with OHCA in our public service area.

When the Public Safety Communications Dispatch Center receives a 911 call, the closest police and fire-rescue personnel are simultaneously dispatched in order to assure that the nearest available AED-equipped responder arrives as soon as possible, and the call is transferred to a hospital-based Emergency Communications Center from which ALS ambulances are dispatched. The first-arriving agency confirms the cardiac arrest, applies an AED, and provides resuscitation according to AHA guidelines. Intervention sequences are provided in a written protocol. EMS personnel obtain on-line medical direction per protocol (e.g. for shock-refractory VF/pVT, defined as confirmed persistent [nonterminating] or recurrent [resuming after termination] of VF/pVT after three or more shocks anytime during resuscitation). Patients with on-scene return of spontaneous circulation (ROSC) are transported to one academic tertiary hospital, ensuring complete follow-up of enrolled patients. We prospectively collected the data according to the Utstein reporting guidelines [12,18,19]. The registry form included age, sex, date, location of cardiac arrest, presence or absence of witnesses, first documented rhythm, presence or absence of bystander cardiopulmonary resuscitation (CPR), defibrillation time and provider (bystander/police/fire-rescue personnel/EMS), as well as outcome measurements, such as pre-hospital ROSC, survival to hospital admission, survival to hospital discharge, and neurological status at hospital discharge [13–16]. All defibrillation times were recorded in real-time by defibrillator data cards and downloaded after the event. Times on the police and fire-rescue cards were synchronized with the Public Safety Communications Dispatch Center. EMS defibrillator times were synchronized daily to the Universal Time Coordinate to be consistent with dispatch times. We defined defibrillation time as the time for the first shock recorded in the time-synchronized defibrillator data cards, and call-to-shock time as the synchronized time interval from the first ring of the 911 call and delivery of the first shock. These procedures enabled calculation of a precise call-to-shock time interval for each event.

Study participants

We included all EMS-treated ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT) cardiac arrest victims in Rochester, MN from 1991 to 2016. We excluded asystole, pulseless electrical activity, and EMS-witnessed VF/pVT from the analysis.

Outcome measure

All patients who survived to hospital admission were prospectively followed to ascertain outcome. Attending physicians evaluated surviving patients at hospital discharge with the Cerebral Performance Category (CPC) scale: category 1, good cerebral performance; category 2, moderate cerebral disability; category 3, severe cerebral disability; category 4, coma or vegetative state; and category 5, death/brain death [12,18,19]. Our outcome measure is neurologically intact survival to hospital discharge, defined as a CPC scale of 1 or 2. Neurocritical care physicians attended all patients who were unresponsive after admission. After 2005, Targeted Temperature Management (TTM) was utilized in all patients who were unresponsive to commands after admission, either to 33C or 36C. Following discharge from the cardiac intensive care unit, a period of in-hospital rehabilitation was available, if deemed warranted by neurocritical care physicians.

Statistical analysis

First, to assess the temporal trend in outcome, we divided the 26-year study into 3 periods, 1991–1997, 1998–2008, and 2009–2016, based on the initiation of the first responder system of police officers in 1991 and fire-rescue personnel in 1998, and the latter period for comparison with our previous report in 2009 [13–16]. Second, we reported patient and cardiac arrest event characteristics overall and for each period with continuous variables as means with standard deviations and categorical variables as percentages. Third, we assessed unadjusted temporal trends in neurologically intact survival to discharge among overall patients and those who survived to hospital admission from all VF arrests and bystander-witnessed VF arrests in 1991–1997, 1998–2008, and 2009–2016. Fourth, we conducted the primary analysis with following logistic regression models: (1) an unadjusted model and (2) an adjusted model for select variables to provide odds ratios (ORs) with 95% confidence intervals (CIs) for each period, using the 1991–1997 period as the reference. We selected potential confounding factors, such as age (continuous), sex (male/female), location of cardiac arrest (home/public place/other), presence of witnesses (yes/no), presence of bystander CPR (yes/no), first defibrillation provider (EMS/police/fire-rescue personnel/bystander), and call to defibrillation time (continuous) based on prior knowledge [3,13,20]. Lastly, we performed the stratified analysis among those who survived to hospital admission, using Firth's logistic regression and same covariates in the