Future Directions
Management of Sudden Cardiac Death

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KEYWORDS

• Cardiac arrest • Cardiopulmonary resuscitation • Postcardiac arrest • Bystander CPR
• Automated external defibrillator • Targeted temperature management • Coronary angiography
• Percutaneous coronary intervention

KEY POINTS

- Incidence of emergency medical service (EMS)-treated out-of-hospital cardiac arrest is approximately 57 per 100,000 population per year in the United States.
- Of EMS-treated out-of-hospital cardiac arrest patients, 9% survive hospital discharge with good neurologic function.
- Optimizing the structure and performance of the system of care for out-of-hospital cardiac arrest is fundamental to improving outcomes.
- A more robust scientific and technological pipeline is needed to optimize the detection and treatment of out-of-hospital cardiac arrest.

INTRODUCTION

Despite current and future advances in preventing sudden cardiac arrest, there will always be a need to optimize early recognition and treatment when cardiac arrest does occur. For out-of-hospital cardiac arrest (OHCA), this requires a complex system of care made up of bystanders, 911 dispatchers, emergency medical service (EMS) providers, and hospital-based providers.[1,2] The structure and performance of these systems of care vary greatly, and each system is only as strong as the weakest link in its chain of survival. In 2015, the Institute of Medicine (IOM) published a report entitled "Strategies to Improve Cardiac Arrest Survival: A Time to Act."[3] This report outlined 8 strategies to improve sudden cardiac arrest survival in the United States (**Box 1**).

The IOM report clearly defines the contemporary challenges in the treatment of cardiac arrest, and provides a strategic framework for improving outcomes. This article highlights the key strategies proposed in the IOM report, reflects on the challenges faced in implementing them, and discusses what might be the most innovative and impactful solutions. Although the IOM report focuses on both OHCA and in-hospital cardiac arrest, this article will focus only on OHCA.

NATIONAL CARDIAC ARREST REGISTRY

National data on the incidence of cardiac arrest are extremely limited. The most fundamental challenge is the inconsistency in definitions used to define the disease. The International Liaison Committee on Resuscitation defines cardiac arrest as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.[4] Because cardiac arrest is the final common pathway of human death, this definition alone does not

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Box 1
Recommendations from the 2015 Institute of Medicine report Strategies to Improve Cardiac Arrest Survival: A Time to Act

1. Establish a national cardiac arrest registry
2. Foster a culture of action through public awareness and training
3. Enhance the capabilities and performance of EMS systems
4. Set national accreditation standards related to cardiac arrest for hospitals and health care systems
5. Adopt continuous quality improvement programs
6. Accelerate research on pathophysiology, new therapies, and translation of science for cardiac arrest
7. Accelerate research on the evaluation and adoption of cardiac arrest therapies
8. Create the National Cardiac Arrest Collaborative

From Committee on the Treatment of Cardiac Arrest: Current status and future directions; Board on Health Sciences Policy; Institute of Medicine; Graham R, McCoy MA, Schultz AM, editors. Strategies to improve cardiac arrest survival: a time to act. Washington (DC): National Academies Press (US); 2015. Available at: https://www.ncbi.nlm.nih.gov/books/NBK305685/. Accessed September 26, 2017; with permission.

discern sudden or unexpected cardiac arrest from the approximately 2.6 million annual deaths in the United States (824 deaths per 100,000 population).[5] The World Health Organization (WHO) defines sudden cardiac death as unexpected, unexplained death within 1 hour of symptom onset for witnessed events, or within 24 hours of last observed alive and symptom-free, for unwitnessed events.[6] Although this definition attempts to select for sudden unexpected death, symptom duration before death is not routinely collected in EMS records and would likely be inaccurate if it was collected and reported. It would also be difficult to reliably associate specific symptoms with subsequent cardiac arrest in many cases. Although the WHO reported that cardiovascular disease was the number one cause of death in 2015 (17.7 million), they did not report on the incidence of sudden cardiac death. The Centers for Disease Control and Prevention (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) database uses 4-digit *International Statistical Classification of Diseases and Related Health Problems*, 10th revision, (ICD-10) codes and 113 cause-of-death recode to determine the cause and location of death. In this database, there were 350,000 annual cases with any mention of cardiac arrest, of which 140,000 occurred in an in-patient facility, leaving approximately 210,000 potentially occurring outside the hospital.[7] The National Institutes of Health-Funded Resuscitation Outcomes Consortium was a North American multicenter clinical research network that collected OHCA incidence and outcome data in defined geographic populations from 2005 to 2015. This group defined cardiac arrests based on whether they were EMS-assessed and whether they were EMS-treated. EMS-assessed included patients who were evaluated by organized EMS personnel and treated (shock delivered or chest compressions by EMS personnel) or not treated by EMS personnel. EMS-treated included only those that were assessed and treated by EMS personnel.[8] In the final year of the Resuscitation Outcomes Consortium (June 2014–May 2015), the incidence of EMS-assessed OHCA was 110.8 per 100,000 population (95% CI 108.9–112.6/100,000) and EMS-treated OHCA was 57.3 per 100,000 population (56.0–58.7/100,000).[7] Extrapolating these results to the entire US population would indicate that there are 356,000 EMS-assessed and 184,000 EMS-treated cardiac arrests annually. These numbers are significantly higher than the CDC estimate. The discrepancy highlights the limitation of reporting OHCA incidence and outcomes based on only EMS-treated patients, which underestimates the incidence, overestimates the survival rate, and is subject to variability when the proportion of EMS-assessed patients that are treated changes. The Cardiac Arrest Registry to Enhance Survival (CARES) is the largest active OHCA registry in the United States. Participation is voluntary. In 2016, CARES collected data on 61,647 EMS-treated OHCAs in the United States. Of these, 20% had an initial cardiac rhythm of ventricular fibrillation or ventricular tachycardia, 41% received bystander cardiopulmonary resuscitation (CPR), 29% had return of spontaneous circulation long enough to be admitted to the hospital, and 9% survived to hospital discharge with good neurologic function. Although the CARES registry has the limitation of collecting data only on EMS-treated patients, it does provide a valuable resource of individual EMS agencies to benchmark the performance of their system of care and annually evaluate the impact of quality improvement programs on process measures and outcomes.

Because preventing sudden cardiac arrest is the most cost-effective strategy, it will be essential to develop mechanisms to accurately monitor and report the incidence of sudden cardiac arrest. However, the fundamental challenge will be to define the patient population that will be included by using characteristics that can be reliably collected and