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Outcomes of sudden cardiac arrest in a state-wide integrated resuscitation program: Results from the Minnesota Resuscitation Consortium☆

Selcuk Adabag[a,b,*], Lucinda Hodgson[b], Santiago Garcia[a], Vidhu Anand[b], Ralph Frascone[c], Marc Conterato[d], Charles Lick[e], Keith Wesley[f], Brian Mahoney[g], Demetris Yannopoulos[b]

[a] Department of Medicine, Division of Cardiology, Minneapolis VA Healthcare System and University of Minnesota School of Medicine, Minneapolis, MN, United States
[b] Department of Medicine, Division of Cardiology, University of Minnesota School of Medicine, Minneapolis, MN, United States
[c] Department of Emergency Medicine, Regions Hospital, St. Paul, MN, United States
[d] Department of Emergency Medicine, North Memorial Medical Center, Robbinsdale, MN, United States
[e] Department of Emergency Medicine, Allina Medical Transportation, St. Paul, MN, United States
[f] Health East Emergency Medical Services, St. Paul, MN, United States
[g] Department of Emergency Medicine, Hennepin County Medical Center, Minneapolis, MN, United States

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ABSTRACT

Background: Despite many advances in resuscitation science the outcomes of sudden cardiac arrest (SCA) remain poor. The Minnesota Resuscitation Consortium (MRC) is a statewide integrated resuscitation program, established in 2011, to provide standardized, evidence-based resuscitation and post-resuscitation care. The objective of this study is to assess the outcomes of a state-wide integrated resuscitation program.
Methods: We examined the trends in resuscitation metrics and outcomes in Minnesota since 2011 and compared these to the results from the national Cardiac Arrest Registry to Enhance Survival (CARES) program. Since 2011 MRC has expanded significantly providing service to >75% of Minnesota's population.
Results: A total of 5192 SCA occurred in counties covered by MRC from 2011 to 2014. In this period, bystander cardiopulmonary resuscitation (CPR) and use of hypothermia, automatic CPR device and impedance threshold device increased significantly ($p < 0.0001$ for all). Compared to CARES, SCA cases in Minnesota were more likely to be ventricular fibrillation (31% vs. 23%, $p < 0.0001$) but less likely to receive bystander CPR (33% vs. 39%, $p < 0.0001$). Survival to hospital discharge with good or moderate cerebral performance (12% vs. 8%, $p < 0.0001$), survival in SCA with a shockable rhythm (Utstein survival) (38% vs. 33%, $p = 0.0003$) and Utstein survival with bystander CPR (44% vs. 37%, $p = 0.003$) were greater in Minnesota than CARES.
Conclusions: State-wide integration of resuscitation services in Minnesota was feasible. Survival rate after cardiac arrest is greater in Minnesota compared to the mean survival rate in CARES.

Introduction

Sudden cardiac arrest (SCA) remains a leading mode of death in the U.S., representing approximately 10–15% of all deaths.[1,2] Except for a few recent encouraging reports,[3–6] survival after SCA has been stagnant around 7–8%, despite decades of research and efforts to improve cardiac resuscitation. However, there is a significant geographical variation in survival rates after SCA in North America.[7,8] One of the potential reasons for this variability could be the lack of a well-coordinated, standardized response among various emergency medical service (EMS) agencies and hospitals.[9] Thus, the American Heart Association (AHA) recommended development of regional systems of care for patients resuscitated from cardiac arrest.[9,10] More recently, the Institute of Medicine (IOM) report on cardiac arrest recommended standard-

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* Corresponding author at: Veterans Affairs Medical Center, Section of Cardiology (111C), One Veterans Drive, Minneapolis, MN 55417, United States. Fax: +1 612 727 5668.
E-mail address: adaba001@umn.edu (S. Adabag).

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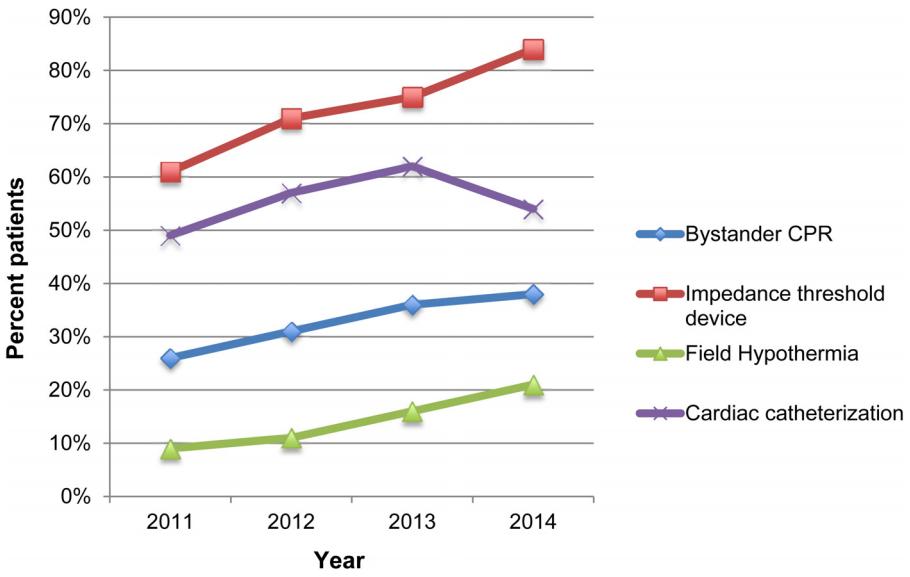

Fig. 1. Temporal trends of key resuscitation variables in Minnesota from 2011 to 2014.

ization of protocols and training and implementation of continuous quality improvement strategies.[11] However, few data exist showing the feasibility and effectiveness of such systems in the U.S.[12,13]

Minnesota Resuscitation Consortium (MRC) was established in 2011 with a grant from Medtronic Heart Rescue Project as a statewide effort to improve survival from SCA in Minnesota (http://www.mrc.umn.edu). The overarching goal of MRC was to gather all stakeholders under the same organization to provide excellent resuscitation and post-resuscitation care in Minnesota via common, evidence-based protocols and to foster an environment of collaboration and continuous improvement among them.[14] As part of the agreement among its members, MRC collects data about the details and outcome of each cardiac arrest using the Cardiac Arrest Registry to Enhance Survival (CARES).[15]

The objectives of this study are to report the trends of resuscitation metrics and outcomes in areas of Minnesota covered by MRC since 2011 and to compare Minnesota's resuscitation outcomes with those from the national CARES program in the U.S.

Methods

Setting

Minnesota (population 5.3 million) is the 12th largest state in the U.S. with a land area of almost 80,000 square miles divided into 87 counties. Based on the 2010 census data, nearly 60% of its residents live in the Minneapolis-St. Paul metro area (population 3.3 million), which is the 16th largest city in the U.S. and has a population density of 515.4 persons/square mile.

Minnesota Resuscitation Consortium

Since its inauguration, MRC has expanded significantly, providing service to greater than 75% of Minnesota's population (Supplemental Fig. 1). Partnering with existing groups and programs, MRC aims to increase public's awareness and bystander response by holding training sessions for cardiopulmonary resuscitation (CPR) and automatic external defibrillator use in schools, workplaces and special events.

MRC gathers first responders, EMS, police and fire departments, hospital emergency departments, cardiology, intensive care unit, neurology, and physical therapy/rehabilitation services under the same organization (Supplemental Fig. 2). It works with EMS directors in the state and an interdisciplinary team of experts from the area hospitals to improve the quality of pre-hospital CPR, to increase the utilization of therapeutic hypothermia, emergency cardiac catheterization and, when necessary, coronary revascularization by implementing standardized and evidence-based protocols.

Data source

To collect data MRC uses an internet-based registry also used by CARES. Details of the SCA are entered through a secure portal by the EMS and the hospitals involved in the care of each patient. These data are reviewed by experienced MRC staff. Cases with a questionable cardiac etiology are referred back with request for more information. The final database is de-identified to respect patient privacy and to enhance provision of unbiased data by the participating agencies.

The CARES program began in 2004 as a cooperative agreement between the Centers for Disease Control and Prevention, the AHA and the Emory University School of Medicine to identify incidents of prehospital cardiac arrest (https://mycares.net/). The CARES utilizes an internet-based registry accessed securely by the participant sites and is designed to help local EMS administrators and medical directors identify the characteristics and monitor the outcomes of SCA to determine the practices and processes associated with success versus those that need improvement.

Study patients

The cases in this study include all patients with SCA who were resuscitated by the EMS participating in MRC from 2011 to 2014. Arrests due to respiratory causes, trauma, submersion, homicide, suicide, drug overdose, asphyxia, exsanguination or any other non-cardiac cause were excluded after reviewing the EMS and hospital records. The final study cohort was 5192 patients with SCA. The comparison group included 129,828 cases of SCA recorded in the national CARES registry during the same period.

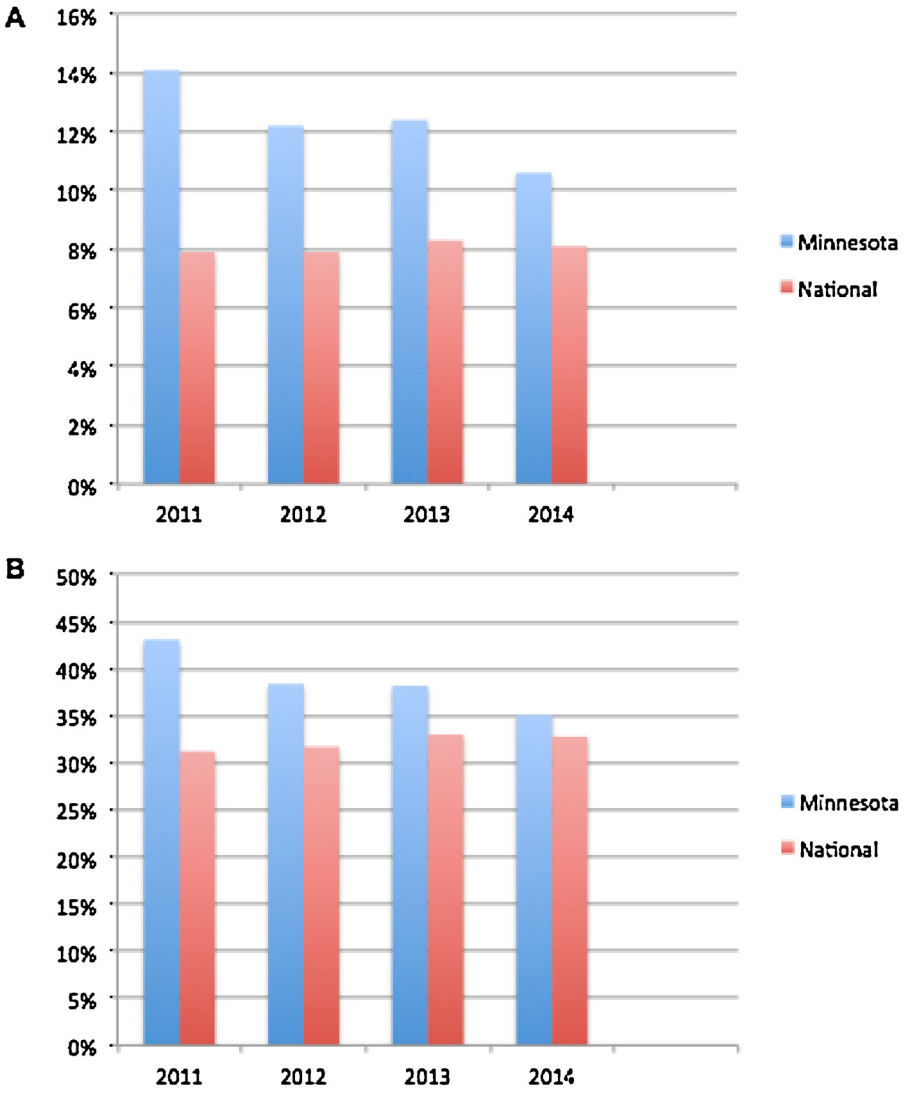

Fig. 2. Temporal trends of key outcomes after cardiac arrest in Minnesota versus national CARES (A) cerebral performance category score 1 or 2 at discharge. (B) Utstein survival of outcomes after cardiac arrest in Minnesota versus national CARES.

Definitions

The MRC and CARES use the SCA definitions developed by the National EMS Information System and the Utstein template.[16,17] A witnessed arrest is one that was seen or heard by another person or an arrest that occurred while the patient was being monitored. Bystander CPR was defined as that performed by a person who is not responding as part of an organized emergency response system. Physicians, nurses and paramedics may be described as performing bystander CPR if they are not part of the emergency response system involved in that patient's resuscitation. Utstein survival was defined as the outcome of a witnessed SCA which had ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT) as the initial rhythm.[13,16]

Neurological outcome at discharge from the hospital was assessed by the cerebral performance category (CPC) score, and CPC 1 or 2 were considered as good outcome.[18,19] CPC score ranges from 1 to 5. CPC 1 refers to good cerebral performance denoting a person who is conscious, alert, is able to work but might have mild neurologic or psychologic deficit. CPC 2 refers to moderate cerebral disability denoting a person who has sufficient cerebral function for independent activities of daily life and is able to work in sheltered environment.[20] S/he might have minor psychological or neurological deficits such as mild dysphasia, non-incapacitating hemiparesis, or minor cranial nerve abnormalities.

Therapeutic hypothermia was defined as any measures taken to reduce the patient's body temperature by non-invasive (administration of cold intravenous saline, external cold pack application to armpits and groin, use of a cooling blanket, torso vest or leg wrap devices) or invasive means (use of cooling catheter inserted in the femoral vein) (Fig. 1).

Statistical analysis

Continuous variables were reported as mean (standard deviation) and categorical variables as percentages. Temporal trends of resuscitation characteristics and outcomes in Minnesota were analyzed with the Cochran–Armitage test for categorical variables and linear regression for continuous variables. Comparisons between Minnesota and national CARES results were made by t-test for continuous variables and chi-square test for categorical variables. All tests were two-tailed and a p value <0.05 was taken as statistically significant (Fig. 2).

Table 1
Temporal trends of resuscitation characteristics and outcomes in Minnesota from 2011 to 2014.

Variables	N available	All cases n = 5192	2011 n = 1067	2012 n = 1207	2013 n = 1440	2014 n = 1473	p-trend
Age, years	5192	64.3 ± 17.1	64.4 ± 17.8	63.2 ± 17.4	64.7 ± 17.0	64.7 ± 16.2	0.24
Female	5192	1750 (34%)	380 (36%)	415 (34%)	461 (32%)	492 (33%)	0.20
Arrest at home	5192	3676 (71%)	715 (67%)	869 (72%)	1018 (71%)	1068 (73%)	0.01
Arrest bystander witnessed	5192	2305 (44%)	442 (41%)	531 (44%)	664 (46%)	661 (45%)	0.06
Arrest 911 witnessed,	5192	561 (11%)	127 (12%)	144 (12%)	130 (9%)	159 (11%)	0.10
Time, 911 call to EMS arrival, minutes	5192	7.5 ± 4.1	6.7 ± 4.3	7.9 ± 3.7	7.6 ± 4.3	7.5 ± 4.1	0.07
Bystander CPR	5192	1718 (33%)	277 (26%)	368 (31%)	514 (36%)	558 (38%)	<0.0001
AED applied	5192	2695 (52%)	554 (52%)	618 (51%)	760 (53%)	763 (52%)	0.8
Initial rhythm VT/VF	5192	1599 (31%)	327 (31%)	377 (31%)	452 (31%)	442 (30%)	0.7
LUCAS™ device	4710	3065 (65%)	228 (48%)	697 (58%)	984 (68%)	1156 (78%)	<0.0001
Impedance threshold device	4708	3541 (75%)	353 (61%)	867 (71%)	1087 (75%)	1234 (84%)	<0.0001
Cardiac catheterization	1276	720 (56%)	68 (49%)	196 (57%)	239 (62%)	217 (54%)	0.5
PCI	714	218 (44%)	40 (60%)	78 (40%)	113 (48%)	87 (42%)	0.2
In-hospital ICD	1262	250 (20%)	28 (21%)	69 (18%)	82 (21%)	71 (18%)	0.5
Field hypothermia	4794	719 (15%)	58 (9%)	131 (11%)	224 (16%)	306 (21%)	<0.0001
Survival to hospital admission	5192	1501 (29%)	343 (32%)	360 (30%)	393 (27%)	405 (27%)	0.004
Survival to hospital discharge	5192	708 (14%)	168 (16%)	165 (14%)	196 (14%)	179 (12%)	0.01
Survived to hospital discharge with good neurological outcome	5192	633 (12%)	150 (14%)	147 (12%)	179 (12%)	157 (11%)	0.02
Utstein survival	1010	386 (38%)	85 (43%)	86 (38%)	115 (38%)	101 (35%)	0.09
Utstein survival with bystander CPR	485	213 (44%)	38 (48%)	50 (47%)	59 (46%)	66 (39%)	0.20

Abbreviations: AED—automated external defibrillator; CPR—cardiopulmonary resuscitation; EMS—emergency medical services; ICD—implantable cardioverter defibrillator; PCI—percutaneous coronary intervention; VT/VF—ventricular tachycardia/ventricular fibrillation.

Results

Mean age of the SCA cases in Minnesota was 64.3 (±17.1) and 34% were female. Overall, 71% of the SCA occurred at home, 55% were witnessed and 33% received bystander CPR (Table 1). The initial rhythm was VF or VT in 31%. Of the 1276 patients with available information, 720 (56%) underwent cardiac catheterization.

Temporal trends of resuscitation characteristics in Minnesota

Temporal trends of selected resuscitation variables and outcomes in Minnesota are displayed in Table 1. From 2011 to 2014, there was a dramatic increase in the proportion of bystander CPR, and in the use of automated CPR device, impedance threshold device and therapeutic hypothermia in the field (Table 1). However, as new EMS agencies joined the MRC, survival to hospital admission and discharge slightly decreased whereas, survival of patients with a shockable rhythm (Utstein survival) and survival of patients with a shockable rhythm *and* bystander CPR did not change appreciably.

Comparison of SCA outcomes in Minnesota versus national CARES

The comparison of the resuscitation characteristics and outcomes in Minnesota versus national CARES is shown in Table 2. Cardiac arrests in Minnesota were more likely to be witnessed, but less likely to receive bystander CPR. The initial rhythm in Minnesota was more likely to be VF or VT than national CARES (31% vs. 23%, $p < 0.0001$). Survival to hospital discharge (14% vs. 11%, $p < 0.0001$) and survival with good neurological outcome (12% vs. 8%, $p < 0.0001$) was significantly higher in Minnesota than national CARES (Table 2). In Minnesota the survival in patients with witnessed arrest and shockable rhythm (Utstein survival) was 38%, which increased to 44% if bystander CPR was performed. In comparison, the corresponding survival values in national CARES, were 33% and 37%, respectively (Table 2).

Discussion

Sudden cardiac arrest remains a major health problem in the general population and in sub-populations with higher-risk features.[21–25] This report shows that creating a large, state-wide integrated resuscitation network in Minnesota was feasible. Since the creation of MRC here was a temporal improvement in many resuscitation metrics including bystander CPR and therapeutic hypothermia in Minnesota. These data also showed that survival rate after SCA in Minnesota was significantly better compared to the average survival at sites participating in the national CARES. Indeed, in Minnesota survival to hospital discharge with good neurological outcome was 12%, survival in patients with a shockable rhythm was 38%, which increased to 44% if bystander CPR was also performed.

Effective care for cardiac arrest requires a coordinated response across various groups, organizations and disciplines including the general public, first responders, EMS and health care facilities (emergency departments, cardiology, intensive care units, neurology, physical therapy and rehabilitation). Attainment of durable success in post-SCA survival with good neurological outcome in a region would require implementing optimal, evidence-based practices at each level of care, designating centers of excellence, creating an environment of communication between all involved parties, initiating a system of data sharing without the fear of repercussion and fostering a culture of continuous quality improvement. Thus, the AHA and the IOM recommended creation of regional systems of care after SCA.[11,26] In 2004 the Arizona Department of Health Services developed a state-wide partnership with EMS agencies to create a standardized regional approach to resuscitation with the eventual goal of improving the outcomes after SCA in the state.[13] After the partnership there was a significant improvement in bystander and EMS care and tripling of survival after SCA statewide.[27,28] Subsequently, in 2007 the partnership created a network of hospitals, named “Cardiac Referral Centers”, that agreed to deliver standardized care after cardiac resuscitation including therapeutic hypothermia, emergency percutaneous coronary interventions and other guideline-based critical care SCA.[13,29] In 2008, the partnership developed protocols allowing the EMS to bypass local hospitals to preferentially transport patients to the cardiac receiving centers, with expertise in caring for patients with SCA.[30,31] As a result of these efforts, the odds of survival after SCA doubled after the intervention in comparison to before.[13] Survival to hospital discharge increased to 14%, survival with good neurological outcome increased to 9% and survival in patients with bystander CPR *and* shockable rhythm increased to 39%. The SCA out-

Table 2
Comparison of the resuscitation characteristics and outcomes in Minnesota versus national CARES.

	Minnesota n = 5192	National CARES n = 129828	P value
Age, years	64.3 ± 17.1	64.3 ± 18.2	0.70
Female	1750 (34%)	49,724 (38%)	<0.0001
Arrest at home	3676 (71%)	89,581 (69%)	0.006
Arrest bystander witnessed	2305 (44%)	49,724 (38%)	<0.0001
Arrest 911 witnessed	561 (11%)	13,762 (11%)	0.70
Bystander CPR	1719 (33%)	50,763 (39%)	<0.0001
AED applied	2695 (52%)	34,664 (27%)	<0.0001
Initial rhythm VT/VF	1599 (31%)	30,120 (23%)	<0.0001
Field hypothermia	774 (15%)	17,397 (13%)	0.002
Survival to hospital admission	1500 (29%)	34,924 (27%)	0.002
Survival to hospital discharge	706 (14%)	13,632 (11%)	<0.0001
Survived to hospital discharge with good neurological outcome	633 (12%)	10,516 (8%)	<0.0001
Utstein survival[a]	1010 (38%)	17825 (33%)	0.0003
Utstein survival with bystander CPR[b]	485 (44%)	10,186 (37%)	0.003

Abbreviations: CPR—cardiopulmonary resuscitation; VT/VF—ventricular tachycardia/ventricular fibrillation; CARES— Cardiac Arrest Registry to Enhance Survival.
[a] Data available for 2637 patients in Minnesota and 54511 patients in national CARES.
[b] Data available for 1105 patients in Minnesota and 27456 patients in national CARES.

comes in Minnesota, which are comparable to those in Arizona and significantly better than the sites participating in national CARES, support this model of regionalization of resuscitation care.

These data showed that the initial rhythm was VF in a significantly greater percentage of SCAs in Minnesota compared to the national average. This is surprising considering the lower bystander response in Minnesota compared to national CARES. Although we cannot be certain about the etiology of this finding based on these data, some potential explanations include the EMS response time <8 min, high quality of CPR including automated compression/decompression device and impedance threshold device.

Strengths and limitations

This study provides data on the outcomes from a regionalized post-SCA response system, suggested by the AHA and the IOM.

There are some limitations to consider. First, there are no systematic data on the outcomes of SCA before the initiation of MRC. Thus, we cannot be certain that the observed outcomes are a result of the regionalization process. However, the similarity of our results to other areas with regionalized response supports this notion. Second, Minnesota is part of the national CARES. Thus, in this analysis cases from Minnesota were also included in the comparison group. However, cases from Minnesota constitutes <4% of the national CARES and their inclusion in the control group only reduces the differences between groups.

Conclusions

In conclusion, a large, state-wide integrated resuscitation network in Minnesota was feasible. After the creation of MRC many resuscitation metrics in Minnesota improved over time. Survival rate after cardiac arrest is greater in Minnesota compared to the mean survival in national CARES.

Conflict of interest statement

Dr. Garcia is the recipient of a career development award (1IK2CX000699-01) from the VA Office of Research and Development. Dr. Garcia is a consultant for Surmodics.

Dr. Yannopoulos is the PI and co-PI for the following NIH (NHLBI) grants: R01 HL123227, 1R01HL126092-01, R01HL1223231, R43HL123194-01 1R43HL110517-01A1, R43HL115937-01. The other authors have no conflicts to report related to this manuscript.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resuscitation.2016.10.029.

References

1. Deo R, Albert CM. Epidemiology and genetics of sudden cardiac death. Circulation 2012;125:620–37.
2. Adabag AS, Peterson G, Apple FS, et al. Etiology of sudden death in the community: results of anatomical, metabolic, and genetic evaluation. Am Heart J 2010;159:33–9.
3. Chan PS, McNally B, Tang F, et al. Recent trends in survival from out-of-hospital cardiac arrest in the United States. Circulation 2014;130:1876–82.
4. Hollenberg J, Herlitz J, Lindqvist J, et al. Improved survival after out-of-hospital cardiac arrest is associated with an increase in proportion of emergency crew-witnessed cases and bystander cardiopulmonary resuscitation. Circulation 2008;118:389–96.
5. Iwami T, Nichol G, Hiraide A, et al. Continuous improvements in chain of survival increased survival after out-of-hospital cardiac arrests: a large-scale population-based study. Circulation 2009;119:728–34.
6. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. JAMA 2013;310:1377–84.
7. Kolte D, Khera S, Aronow WS, et al. Regional variation in the incidence and outcomes of in-hospital cardiac arrest in the United States. Circulation 2015;131:1415–25.
8. Nichol G, Thomas E, Callaway CW, et al. Regional variation in out-of-hospital cardiac arrest incidence and outcome. JAMA 2008;300:1423–31.
9. Nichol G, Aufderheide TP, Eigel B, et al. Regional systems of care for out-of-hospital cardiac arrest: a policy statement from the American Heart Association. Circulation 2010;121:709–29.
10. Stiell IG, Wells GA, Field BJ, et al. Improved out-of-hospital cardiac arrest survival through the inexpensive optimization of an existing defibrillation program: OPALS study phase II. Ontario prehospital advanced life support. JAMA 1999;281:1175–81.
11. IOM. Strategies to Improve Cardiac Arrest Survival: A Time to Act. IOM; 2015 http://iom.nationalacademies.org/Reports/2015/Strategies-to-Improve-Cardiac-Arrest-Survival.aspx.
12. Haukoos JS, Witt G, Gravitz C, et al. Out-of-hospital cardiac arrest in Denver, Colorado: epidemiology and outcomes. Acad Emerg Med 2010;17:391–8.
13. Spaite DW, Bobrow BJ, Stolz U, et al. Statewide regionalization of postarrest care for out-of-hospital cardiac arrest: association with survival and neurologic outcome. Ann Emerg Med 2014;64:496–506.
14. Garcia S, Drexel T, Bekwelem W, et al. Early access to the cardiac catheterization laboratory for patients resuscitated from cardiac arrest due to a shockable rhythm: the Minnesota Resuscitation Consortium twin cities unified protocol. J Am Heart Assoc 2016;5, pii: e002670.
15. McNally B, Robb R, Mehta M, et al. Centers for disease control and prevention. Out-of-hospital cardiac arrest surveillance—Cardiac Arrest Registry to Enhance

Survival (CARES), United States, October 1, 2005–December 31, 2010. MMWR Surveill Summ 2011;vol. 60:1–19.
16. Cummins RO, Chamberlain DA, Abramson NS, et al. Recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest: the Utstein Style. A statement for health professionals from a task force of the American Heart Association, the European Resuscitation Council, the Heart and Stroke Foundation of Canada, and the Australian Resuscitation Council. Circulation 1991;84:960–75.
17. Jacobs I, Nadkarni V, Bahr J, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update and simplification of the Utstein templates for resuscitation registries: a statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian Resuscitation Council, New Zealand Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Councils of Southern Africa). Resuscitation 2004;63:233–49.
18. Rubertsson S, Lindgren E, Smekal D, et al. Mechanical chest compressions and simultaneous defibrillation vs conventional cardiopulmonary resuscitation in out-of-hospital cardiac arrest: the LINC randomized trial. JAMA 2014;311:53–61.
19. Frascone RJ, Wayne MA, Swor RA, et al. Treatment of non-traumatic out-of-hospital cardiac arrest with active compression decompression cardiopulmonary resuscitation plus an impedance threshold device. Resuscitation 2013;84:1214–22.
20. Ajam K, Gold LS, Beck SS, et al. Reliability of the cerebral performance category to classify neurological status among survivors of ventricular fibrillation arrest: a cohort study. Scand J Trauma Resusc Emerg Med 2011;19:38.
21. Adabag S, Huxley RR, Lopez FL, et al. Obesity related risk of sudden cardiac death in the atherosclerosis risk in communities study. Heart 2015;101:215–21.
22. Adabag S, Rector TS, Anand IS, et al. A prediction model for sudden cardiac death in patients with heart failure and preserved ejection fraction. Eur J Heart Fail 2014;16:1175–82.
23. Vakil K, Taimeh Z, Sharma A, et al. Incidence, predictors, and temporal trends of sudden cardiac death after heart transplantation. Heart Rhythm 2014;11:1684–90.
24. Adabag AS, Therneau TM, Gersh BJ, et al. Sudden death after myocardial infarction. JAMA 2008;300:2022–9.
25. Adabag S, Smith LG, Anand IS, et al. Sudden cardiac death in heart failure patients with preserved ejection fraction. J Card Fail 2012;18:749–54.
26. Neumar RW, Eigel B, Callaway CW, et al. The American Heart Association Response to the 2015 Institute of Medicine Report on Strategies to improve cardiac arrest survival. Circulation 2015;132:1049–70.
27. Bobrow BJ, Spaite DW, Berg RA, et al. Chest compression—only CPR by lay rescuers and survival from out-of-hospital cardiac arrest. JAMA 2010;304:1447–54.
28. Bobrow BJ, Clark LL, Ewy GA, et al. Minimally interrupted cardiac resuscitation by emergency medical services for out-of-hospital cardiac arrest. JAMA 2008;299:1158–65.
29. Donnino MW, Rittenberger JC, Gaieski D, et al. The development and implementation of cardiac arrest centers. Resuscitation 2011;82:974–8.
30. Sunde K, Pytte M, Jacobsen D, et al. Implementation of a standardised treatment protocol for post resuscitation care after out-of-hospital cardiac arrest. Resuscitation 2007;73:29–39.
31. Davis DP, Fisher R, Aguilar S, et al. The feasibility of a regional cardiac arrest receiving system. Resuscitation 2007;74:44–51.