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Rationale, Development and Implementation of the Resuscitation Outcomes Consortium Epistry–Cardiac Arrest

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Abstract

Objective—To describe the development, design and consequent scientific implications of the Resuscitation Outcomes Consortium (ROC) population-based registry; ROC Epistry–Cardiac Arrest.

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Nonauthor contributions outlined in Online Appendix 1

Conflict of interest: None

Methods—The ROC Epistry–Cardiac Arrest is designed as a prospective population-based registry of all Emergency Medical Services (EMS)-attended 9-1-1 calls for patients with out-of-hospital cardiac arrest occurring in the geographical area described by the eight US and three Canadian regions. The data set was derived by an North American interdisciplinary steering committee. Enrolled cases include individuals of all ages who experience cardiac arrest outside the hospital, with evaluation by organized EMS personnel and: a) attempts at external defibrillation (by lay responders or emergency personnel), or chest compressions by organized EMS personnel; OR b) were pulseless but did not receive attempts to defibrillate or CPR by EMS personnel. Selected data items are categorized as mandatory or optional and undergo revisions approximately every 12 months. Where possible all definitions are referenced to existing literature. Where a common definition did not exist one was developed. Optional items include standardized CPR process data elements. It is anticipated the ROC Epistry–Cardiac Arrest will enroll between approximately 9000 and 13,500 treated all rhythm arrests and 4000 and 5000 ventricular fibrillation arrests annually and approximately 8000 EMS-attended but untreated arrests.

Conclusion—We describe the rationale, development, design and future implications of the ROC Epistry–Cardiac Arrest. This paper will serve as the reference for subsequent ROC manuscripts and for the common data elements captured in both ROC Epistry–Cardiac Arrest and the ROC trials.

Keywords

emergency medical services; prehospital; outcome; out-of-hospital; cardiac arrest; registry

Introduction

Out-of-hospital cardiac arrest is a large public health problem that accounts for hundreds of thousands of deaths annually in North America. Patient and care characteristics can predict favourable outcome and this understanding has been incorporated in efforts to improve resuscitation.^{1–4} EMS-treated out-of-hospital cardiac arrest survival figures across communities varies approximately 12-fold for both all-rhythms arrests (1.8%–21.5%) and arrests presenting with ventricular fibrillation (3.3–40.5%).^{2, 5–8}

Understanding this heterogeneity provides the foundation for improving the care and outcome for cardiac arrest and in turn may impact this public health challenge. A population-based registry of out-of-hospital cardiac arrest enables assessment of how evidence-based resuscitation is implemented in community-based practice. In other disease states registries have provided invaluable resources to establish novel prognostic measures that may serve to further the understanding of the pathophysiology or guide patient care.^{1, 3, 5, 6, 9}

To date, no single North American population-based registry from multiple communities exists for out-of-hospital cardiac arrest. The Resuscitation Outcomes Consortium (ROC) is supported to conduct randomized clinical trials evaluating promising treatment interventions for out-of-hospital cardiac arrest and life-threatening trauma.¹⁰ The objective of this paper is to describe the development, design and consequent scientific implications of the

Resuscitation Outcomes Consortium cardiac arrest population-based registry referred to as the ROC Epistry–Cardiac Arrest.

Epistry Background and Process

Literature Review

A comprehensive review of the world literature was conducted to identify existing out-of-hospital registries and population-based datasets. This search strategy included all English literature published from 1996 and 2004 and tracked in MEDLINE, EMBASE CINAHL, or Health Star. The search strategy used the terms pre-hospital or prehospital, ambulance(s), paramedic(s), or Emergency Medical Technician(s), Emergency Medical Services, data collection, Medical Records Systems, computerized or patient care record database, integrate, registry or registries and English only publications. The Journal of Medical Internet Research was manually searched. The search results of the various sources and internet resources are listed in Table 1.

Consensus Building

An interdisciplinary working group of ROC personnel convened weekly by conference call over a 15 month period from September 15, 2004 to November 30, 2005 to develop the ROC Epistry–Cardiac Arrest data elements and definitions (Online Appendix 2). The group identified a comprehensive list of variables and classified them as mandatory, optional or unnecessary. Consensus definitions and response options were developed for each variable, incorporating previously published or modified definitions when necessary from National EMS Information System (NEMSIS)¹¹ and the Utstein templates^{12–14} to better achieve uniform reporting and enable EMS services to map their data to the ROC Epistry – Cardiac Arrest.

ROC Site Implementation and Data Management Strategy

Each site consulted widely with stakeholders to collate source documents, optimize timely data flow, abstract, verify, and enter data. De-identified data were sent to the Data Coordinating Center through direct web entry or batch upload from existing, new or merged datasets (Online Appendix 3).

Methods

Design

ROC Epistry–Cardiac Arrest was designed as a prospective population-based cohort study.

Setting

The ROC Epistry–Cardiac Arrest data included all EMS-attended 9-1-1 calls for patients with out-of-hospital cardiac arrest occurring in eight US regions (Alabama, Dallas, Iowa, Milwaukee, Pittsburgh, Portland, San Diego, and Seattle/King County), and three Canadian regions (Ottawa, Toronto, and British Columbia) with one data coordinating center (University of Washington) (Fig. 1). Approximately 23.7 million persons were served by the participating EMS agencies from the 11 ROC geographic areas (Table 2)¹⁵. Aeromedical

calls were included if they occurred in the geographical area covered by a ROC land ambulance service. (Fig. 2)

Study Population (Inclusion Criteria)

The ROC Epistry–Cardiac Arrest was designed to include individuals of all ages who experience cardiac arrest outside the hospital, with evaluation by organized EMS personnel and: a) attempts at external defibrillation (by lay responders or emergency personnel), or chest compressions by organized EMS personnel; OR b) were pulseless but did not receive attempts to defibrillate or CPR by EMS personnel. This latter group includes patients for whom resuscitation was not attempted because there was clear evidence confirming death such as rigor mortis or because of a ‘do not attempt resuscitation’ directive authorized by a physician, or for compelling reasons that included extensive history of terminal illness or intractable disease, and/or a request from the patient’s family.

Variables

Selected data items were categorized as mandatory (Table 3) or optional and the Online Appendix 2 lists their definitions and reference source.

Examples of Important Mandatory Variables

Geospatial Measures—Geospatial measures from the scene of arrest (i.e., census tract, latitude/longitude coordinates, Universal Transverse Mercator Grid) were included in the ROC Epistry–Cardiac Arrest to provide surrogate measures for socioeconomic status, location of arrest, as well as potential Geographic Information System (GIS) analyses.

EMS Time Zero—EMS response intervals are related to outcome but there is substantial potential for misclassification across sites depending on how the interval is measured. The most scientifically-relevant EMS response interval is the interval between the call for help (first ring to 9-1-1) and the delivery of first EMS care (i.e., CPR or defibrillation). The call received time at 9-1-1 was not uniformly available across all sites. However, call received at a dedicated EMS dispatch downstream from the 911 access point was uniformly available and became a mandatory data item and our best estimate of EMS time zero..

Etiology of Arrest—Arrests were classified as “obvious” cause when the circumstances and evidence clearly supported such an etiology (i.e., arrest in a patient with a known toxic ingestion). Etiology was classified as “no obvious cause” for arrests where the cause was uncertain or where there was evidence of a primary cardiac etiology.

Treated vs. Untreated Cardiac Arrest: Defining the Denominator—To ensure the uniformity of reporting the survival rate, all cases were categorized as either EMS-attended and treated or EMS-attended but not treated. Those not treated were additionally classified into 3 different categories; 1) Obviously dead by legal legislation, 2) Do not resuscitate (verbal or written), and 3) considered futile and resuscitation not started.

Prehospital Disposition: Defining Prehospital Outcome—Prehospital disposition was captured as; 1) legally dead (obvious death by legal legislation became obvious after

resuscitation began), 2) expected death (advance directive became available during the resuscitation) and 3) resuscitation stopped due to futility (failure to respond to treatment in the field or *en route* to hospital by protocol) in addition to cases where 4) resuscitation was terminated when the patient achieved a return of spontaneous circulation.

Inhospital Disposition or Vital Status; Defining Inhospital Outcome—Hospital outcome included day, month, year and time of death or discharge. Patients who were transferred to another acute care facility (e.g., to undergo ICD placement or angiography) were considered to be still hospitalized and outcome from this institution was sought as well. This process was repeated until it was confirmed that the patient was discharged home or to a non-acute ward or facility at which point they were considered discharged.

CPR Process—Some CPR process measures can now be derived from defibrillator recordings using a combination of software interpretation and expert review. A standardized approach to data abstraction was developed (Table 4).

Case Identification

Each ROC site had to ensure capture of all eligible cases. Examples of case identification strategies include regular hand sorting through paper EMS charts (up to 1000 charts per day in some sites), electronic queries of EMS records by a variety of data fields; i.e., dispatch call type, vital signs, diagnosis, NEMSIS¹¹ codes, or a combination of these fields.

Data Capture

In sites with access to an electronic dataset, charts were reviewed locally and augmented with targeted review of the EMS patient care report to complete the required data elements and check for data errors. Where no appropriate database currently existed, processes were put in place to funnel primary source materials to the data abstractor. Data capture occurred through a web based interface or through batch upload from sites with an electronic database. Inhospital data were abstracted directly from the hospital file in most cases. Alternative methods included death registries and obituaries if the death occurred within 30 days of the prehospital event. Vital status was deemed missing if unconfirmed.

Quality Assurance

Site-specific quality assurance plans included: initial EMS provider training in data collection, continuing education of EMS providers for certain variables and definitions (e.g. bystander CPR), site and Data Coordinating Center review of randomly selected records to confirm accuracy of data entry, and data element range and consistency checks in both the web-based data entry forms and the batch upload process. In addition, the Data Coordinating Center conducted annual site visits to further review a portion of entered records, data capture processes, and site-specific mechanisms for quality assurance.

Human Subjects Protection and Regulatory Issues

This observational study based on existing data sources (i.e., EMS and hospital records), met requirements for minimal risk research in the United States¹⁶ and Canada.¹⁷ This protocol was reviewed and approved by 74 US Institutional Review Boards and 34 Canadian

Research Ethics Boards as well as 26 EMS Services Institutional Review Boards. In addition approval in the form of a memorandum of understanding for data sharing was acquired from 24 hospitals and from 94 EMS services. The ROC data safety and monitoring board (DSMB) provided semi annual review.

Sample Size and Statistical Power

Participating sites provided preliminary estimates of incidence and outcome for EMS-attended arrests from heterogeneous sources for the purposes of planning. Overall the cumulative number of EMS-attended arrests was estimated at 17,500 among a population of 23.7 million persons, or an incidence of 76 arrests per 100,000 with an average survival of 5.6%. Substantial site-based variation was present in these estimates; for example preliminary estimates of site-based incidence varied from 44 to 114 EMS-attended arrests per 100,000 person-years. These preliminary estimates differed from published estimates of incidence of EMS-treated, all-rhythm cardiac arrest of 37/100,000 and 55/100,000 persons and ventricular fibrillation arrest of between 17/100,000 and 21/100,000.^{5-8, 18-20} A standardized population-based registry of this size would assure sufficient analytical power to address a variety of important but unanswered questions.

Limitations

Some ROC Epistry-Cardiac Arrest variable definitions and abstraction instructions were not validated prior to implementation. Although not ideal, this approach incorporated review of the scientific literature and careful consensus by the working group. Like all observational studies, causal inference cannot be definitively established using the ROC Epistry-Cardiac Arrest. Nonetheless, many important clinical questions cannot be readily addressed by clinical trials. Moreover, when carefully conducted, observational studies can provide an estimate of effect that is often consistent with the results of clinical trials.²¹⁻²⁴ And finally, although efforts in design and implementation sought optimal consistency and comprehensiveness, the heterogeneity of episode identification and monitoring of EMS process of care could limit internal and external validity.

Discussion

The ROC Epistry-Cardiac Arrest data set was derived through an North American interdisciplinary collaboration of ROC investigators, EMS liaisons and study staff. The data variables and definitions were based from the literature and when possible included established data definitions and collection processes. Throughout the process of design and implementation, the ROC Epistry-Cardiac Arrest working group strove to balance scientific merit with the ability to obtain reliable and meaningful measurement. Existing cardiac arrest registries do not contain the necessary information to adequately determine the incidence of out-of-hospital cardiac arrest nor determine which patient, circumstance, and treatment characteristics influence survival following out-of-hospital cardiac arrest. For example, the National Registry for Cardiopulmonary Resuscitation was developed in the United States to collate the descriptions of in-hospital cardiopulmonary arrest events.²⁵ As of April 27, 2007, this in-hospital cardiac arrest registry included more than 100,000 events that received some

form of resuscitation.(Personal communication, NRCPR Investigators, April 27, 2007)
However, events that occur out-of-hospital were excluded from this database.

The National Highway and Traffic Safety Agency (NHTSA) supported the development of data elements to describe structure and process related to EMS care.¹¹ Although each state's EMS director committed to collecting these data elements, at the time of this study no secure and confidential method of collating information into a single dataset existed. Additionally, the NEMSIS data did not include status at hospital discharge, which is critical to ascertain the burden of illness, the outcomes of interventions trials, and the quality of EMS practices.

International consensus panels of resuscitation experts have developed Utstein templates for reporting outcomes after cardiac arrest;^{12–14} however these templates have not been universally applied in all ROC sites. Until recently, the cardiac arrest template lacked simple and universal operational definitions of structure, process and outcome.¹² The population of approximately 23.7 million people served by EMS services participating in ROC will produce thousands of EMS-treated cardiac arrests per year. This substantial database will enable a variety of important clinical questions to be readily addressed. In the followings sections, we illustrate potential uses for the ROC Epistry–Cardiac Arrest that may impact our understanding of resuscitation and in turn direct further research or resources for care.

ROC Epistry: Understanding differences in outcome

Variability in EMS Systems—Understanding the causes for substantial differences in survival from out-of-hospital cardiac arrest exist across communities may provide the basis to focus or refine care and in turn improve public health. A number of factors have influenced incidence estimates based on EMS treated cardiac arrest, including demographics and geography of the community^{2, 26} and variation in practices of activating 9-1-1. Variability in EMS threshold for initiating resuscitation has influenced the denominator on which both incidence and survival are estimated.²⁷ Differences in citizen activation of 9-1-1, CPR and Public Access Defibrillation rates may influence initiation of resuscitation. In addition to variability in resuscitation practices, there may be a difference in how arrests of cardiac etiology are coded in EMS data sets.¹⁸ Reflexively, investigators and policy makers may attribute differences to health services characteristics such as EMS response intervals or the frequency of layperson CPR. However, the degree to which these links in the chain of survival are responsible for these differences is not clear. Moreover, accurate capture of these intervals will enable more productive investigation of how the 3-phase (time-dependent) model of arrest may be integrated and exploited to improve resuscitation.²⁸ A single population-based registry from multiple communities provides the opportunity for this assessment only if these time intervals are defined and collected in a standard fashion.

Common Denominator—The difference in reported survival rates in the literature may be related to the lack of a common denominator. Depending on the report or community, the denominator may consist of only cases initially presenting with ventricular fibrillation, EMS-treated cases regardless of presenting rhythm, or all cases of EMS-attended arrest consisting of those who are treated and those where resuscitation is not attempted. The current ROC Epistry - Cardiac Arrest design will enable capture and comparison with a

consistent and uniform denominator which will enable valid comparison and in turn may allow for a better understanding of characteristics that influence outcome.

True Incidence—Case surveillance is a core imperative to derive a population-based assessment of the burden of out-of-hospital cardiac arrest and potential characteristics that improve survival. Some prior studies have indicated that as incidence increases, survival decreases. How this factor influences community survival is not clear. The ROC Epistry–Cardiac Arrest should shed light on this issue as it will collect information on all EMS-attended arrests, EMS-treated and -untreated.

CPR Performance—The ROC Epistry–Cardiac Arrest also provides the basis to explore promising treatment predictors. Given accumulating evidence, CPR can no longer be considered a simple yes/no categorical variable but is a complex and dynamic activity. The ROC Epistry–Cardiac Arrest will capture some of the measures of CPR process such as compression rate and hands-off time so that we can better understand if-CPR performance influences outcome.

Novel Predictors—The ROC Epistry–Cardiac Arrest may also be used as a platform to address other novel predictors. Socioeconomic status has been related to a variety of conditions regarding disease incidence, healthcare delivery, and health outcomes. Given the growing evidence supporting public access defibrillation and hypothermia treatment, we must evaluate and in turn address whether socioeconomic disparity influences such treatment or outcome.

Important Subgroup—Children are an important subset and as such are included in ROC Epistry–Cardiac Arrest included in the ROC Epistry–Cardiac Arrest. Although infrequent, cardiac arrest in children is especially devastating. Because it is uncommon, efforts to effectively study this subgroup has been challenging, often limiting the ability to answer important scientific questions definitively. Efforts to study these types of subgroups often require data to accrue over decades. Epistry will draw from a sufficiently large population and in turn should be able in a relatively timely manner to address important questions pertaining to this subgroup. Treatments that are appropriate for clinical subgroups beg the question of what proportion of all cardiac arrests will potentially benefit from this intervention. The ROC Epistry–Cardiac Arrest provides the basis for this assessment.

Knowledge Translation—Translation of this evidence to community-based practice can be challenging and represents a critical required step for improving public health.^{6, 7} Importantly, clinical research often is restricted to target populations with specific eligibility characteristics and the results may not be generalized to community based practice. Alternatively, economic or expertise considerations may hinder the broad implementation of evidence-based care. Such considerations are potentially relevant when implementing programs of public access defibrillation or hypothermia, ultimately limiting the potential benefit to society. The ROC Epistry–Cardiac Arrest provides a population-based method to monitor translation of this science as well as emerging standards related to such areas as CPR process.

Conclusion

We describe the rationale, development, design and potential usefulness of ROC Epistry-Cardiac Arrest. This paper will serve as the reference for subsequent ROC manuscripts both descriptive and inferential and for the common data elements captured in both ROC Epistry-Cardiac Arrest and the ROC randomized controlled trials when applicable. The design and implementation was an iterative, collaborative process that served as a basis to address important epidemiologic and clinical questions involving cardiac arrest. The findings of such questions may provide insights that can influence care and improve public health.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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*These individuals contributed significantly to version one ROC Epistry- Cardiac Arrest. Specifically they were responsible for merging of the definitions from various sources in the literature (JennL, GS), tracking the changes to the document generated through the consensus building process (JF) creating the data dictionary and manual of operation (GS), and writing the ethics section of the protocol (JimL). We also want to thank the many contributing EMS agencies, EMS providers, study coordinators, staff, and other investigators (see Appendix 1) for their willingness to participate in and support this project, and for their continued dedication to improving the EMS care and outcomes for their patients.

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References

1. Herlitz J, Ekstrom L, Wennerblom B, Axelsson A, Bang A, Holmberg S. Prognosis among survivors of prehospital cardiac arrest. *Ann Emerg Med.* 1995 Jan; 25(1):58–63. [PubMed: 7802371]
2. Becker LB, Han BH, Meyer PM, et al. Racial differences in the incidence of cardiac arrest and subsequent survival. The CPR Chicago Project. *N Engl J Med.* 1993 Aug 26; 329(9):600–606. [PubMed: 8341333]
3. Stiell IG, Wells GA, DeMaio VJ, et al. Modifiable factors associated with improved cardiac arrest survival in a multicenter basic life support/defibrillation system: OPALS Study Phase I results. Ontario Prehospital Advanced Life Support. *Ann Emerg Med.* 1999 Jan; 33(1):44–50. [PubMed: 9867885]
4. Soo LH, Gray D, Young T, Skene A, Hampton JR. Influence of ambulance crew's length of experience on the outcome of out-of-hospital cardiac arrest. *Eur Heart J.* 1999 Apr; 20(7):535–540. [PubMed: 10365290]
5. Nichol G, Steen P, Herlitz J, et al. International Resuscitation Network Registry: design, rationale and preliminary results. *Resuscitation.* 2005 Jun; 65(3):265–277. [PubMed: 15919562]

6. Rea TD, Crouthamel M, Eisenberg MS, Becker LJ, Lima AR. Temporal patterns in long-term survival after resuscitation from out-of-hospital cardiac arrest. *Circulation*. 2003 Sep 9; 108(10): 1196–1201. [PubMed: 12939219]
7. Rea TD, Eisenberg MS, Becker LJ, Murray JA, Hearne T. Temporal trends in sudden cardiac arrest: a 25-year emergency medical services perspective. *Circulation*. 2003 Jun 10; 107(22):2780–2785. [PubMed: 12756155]
8. Vaillancourt C, Stiell IG. Cardiac arrest care and emergency medical services in Canada. *Can J Cardiol*. 2004 Sep; 20(11):1081–1090. [PubMed: 15457303]
9. Psaty BM, Furberg CD, Kuller LH, et al. Isolated systolic hypertension and subclinical cardiovascular disease in the elderly. Initial findings from the Cardiovascular Health Study. *Jama*. 1992 Sep 9; 268(10):1287–1291. [PubMed: 1387172]
10. Resuscitation Outcomes Consortium. Seattle, Washington: University of Washington, Clinical Trials Center; 2004. [web site]
11. National Emergency Medical Services Information System. web site] <http://www.nemsis.org/dataElements/index.html>.
12. 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). *Circulation*. 2004 Nov 23; 110(21):3385–3397. [PubMed: 15557386]
13. Cummins RO, Chamberlain D, Hazinski MF, et al. Recommended guidelines for reviewing, reporting, and conducting research on in-hospital resuscitation: the in-hospital "Utstein style". American Heart Association. *Ann Emerg Med*. 1997 May; 29(5):650–679. [PubMed: 9140252]
14. Zaritsky A, Nadkarni V, Hazinski MF, et al. Recommended guidelines for uniform reporting of pediatric advanced life support: the pediatric Utstein Style. A statement for healthcare professionals from a task force of the American Academy of Pediatrics, the American Heart Association, and the European Resuscitation Council. Writing Group. *Circulation*. 1995 Oct 1; 92(7):2006–2020. [PubMed: 7671387]
15. Davis DP, Garberson LA, Andrusiek DL, et al. A descriptive analysis of Emergency Medical Service Systems participating in the Resuscitation Outcomes Consortium (ROC) network. *Prehosp Emerg Care*. 2007 Oct-Dec; 11(4):369–382. [PubMed: 17907019]
16. Federal policy for the protection of human subjects. Final rule. Technology OoSa, ed. Vol 56: Federal Register. 1991:28003–28018.
17. Tri-Council policy statement: Ethical Conduct for Research Involving Humans. web based].
18. Rea TD, Eisenberg MS, Sinibaldi G, White RD. Incidence of EMS-treated out-of-hospital cardiac arrest in the United States. *Resuscitation*. 2004 Oct; 63(1):17–24. [PubMed: 15451582]
19. Herlitz J, Eek M, Holmberg M, Holmberg S. Diurnal, weekly and seasonal rhythm of out of hospital cardiac arrest in Sweden. *Resuscitation*. 2002 Aug; 54(2):133–138. [PubMed: 12161292]
20. Atwood C, Eisenberg MS, Herlitz J, Rea TD. Incidence of EMS-treated out-of-hospital cardiac arrest in Europe. *Resuscitation*. 2005 Oct; 67(1):75–80. [PubMed: 16199289]
21. Hlatky MA, Califf RM, Harrell FE Jr, Lee KL, Mark DB, Pryor DB. Comparison of predictions based on observational data with the results of randomized controlled clinical trials of coronary artery bypass surgery. *J Am Coll Cardiol*. 1988 Feb; 11(2):237–245. [PubMed: 3276752]
22. Ioannidis JP, Haidich AB, Pappa M, et al. Comparison of evidence of treatment effects in randomized and nonrandomized studies. *Jama*. 2001 Aug 15; 286(7):821–830. [PubMed: 11497536]
23. Ioannidis JP, Lau J. Completeness of safety reporting in randomized trials: an evaluation of 7 medical areas. *Jama*. 2001 Jan 24–31; 285(4):437–443. [PubMed: 11242428]
24. Benson K, Hartz AJ. A comparison of observational studies and randomized, controlled trials. *N Engl J Med*. 2000 Jun 22; 342(25):1878–1886. [PubMed: 10861324]

25. Peberdy MA, Kaye W, Ornato JP, et al. Cardiopulmonary resuscitation of adults in the hospital: a report of 14720 cardiac arrests from the National Registry of Cardiopulmonary Resuscitation. *Resuscitation*. 2003 Sep; 58(3):297–308. [PubMed: 12969608]
26. Gillum RF. Trends in acute myocardial infarction and coronary heart disease death in the United States. *J Am Coll Cardiol*. 1994 May; 23(6):1273–1277. [PubMed: 8176083]
27. Becker LB, Pepe PE. Ensuring the effectiveness of community-wide emergency cardiac care. *Ann Emerg Med*. 1993 Feb; 22(2 Pt 2):354–365. [PubMed: 8434834]
28. Weisfeldt ML, Becker LB. Resuscitation after cardiac arrest: a 3-phase time-sensitive model. *Jama*. 2002 Dec 18; 288(23):3035–3038. [PubMed: 12479769]

Figure 1.
Geographic location of the 11 Regional Coordinating sites and 1 Data Coordinating site contributing to the ROC Trauma Epistry.

Figure 2. Schematic of the ROC Trauma Epistry geographic “footprint” for sampling patients relative to ground and air medical agency coverage areas.

Table 1

Search Results

Literature Databases	EMbase ²⁹⁻³⁴
	MEDLINE ^{29-31, 35-68}
	CINAHL (1982 – 2004) ^{31, 37, 69-74}
	Health Star (1987– 2004) ^{29, 75-78}
	Journal of Medical Internet Schacht Hansen M http://www.jmir.org/2001/ accessed May 28 2007)
Websites	
EMS Datasets	http://www.nemsis.org/index.html accessed September 2004
Inhospital Datasets	<ul style="list-style-type: none"> National Registry for Cardio Pulmonary Resuscitation (U.S.A.) http://www.nrcpr.org/nrcpr.html accessed September 2004 National Ambulatory Care Reporting System (Canada) http://www.cihi.ca/cihiweb/dispPage.jsp?cw_page=services_nacrs_e accessed September 2004 Center for Clinical Epidemiology National Board of Health and Welfare (Sweden) http://www.sos.se/epc/epceng.htm accessed September 2004

Table 2

Description of the 11 Resuscitation Outcomes Consortium sites contributing to the ROC Epistry- Cardiac Arrest database.¹⁵

ROC Site	Service area population*	Geographic Area (sq miles)*	Number of EMS agencies	Number of Hospitals
Birmingham, AL	644,701	1,328	13	14
British Columbia	2,779,373	1,733	39	33
Dallas, TX	1,989,357	627	11	22
Iowa	1,015,347	2,614	19	19
Milwaukee, WI	940,164	242	16	16
Ottawa	4,030,696	13,213	39	37
Pittsburgh, PA	935,967	2,362	6	38
Portland, OR	1,751,119	4,059	15	16
San Diego, CA	2,297,334	2,059	39	19
Seattle, WA	1,666,978	1,060	35	18
Toronto	5,627,021	6,180	32	55
Total	23,678,057	35,477	264	287

* If an agency's service area followed the geographic boundaries of a town, city, or county, population figures were obtained from the 2000 U.S. Census and the 2001 Canadian Census. The areas served by some of the U.S. agencies did not follow the geographic boundaries of a specific town, city, or county. Population figures for those agencies were based on the census tracts within the service area.

Table 3

Mandatory variables included in the ROC Epistry: Cardiac Arrest database.*

Prehospital	
Episode-specific factors:	Time call received at dispatch [†] Responding EMS agencies and vehicles Time of arrival for each vehicle Number of EMS providers Highest EMS provider service levels Criteria for Epistry enrolment Concomitant clinical trial participation Date of service Prehospital times (16) Geospatial location of event Public versus private location of event
Demographics:	Age Gender Race/ethnicity
Clinical information:	Witnessed by EMS or bystanders EMS chest compressions Bystander resuscitation attempts (CPR or AED/defib) Drug therapies (5) Etiology of arrest—field classification Etiology of arrest—site classification Contributing factors Evidence of implantable defibrillator
Prehospital Intravenous:	Intravenous/intraosseous line placement Fluid therapy Airway interventions Cardiopulmonary resuscitation Hypothermia therapy Advanced monitoring
Prehospital disposition:	Died at scene or en route (noted with or without EMS treatment) Reason not treated or why treatment halted Alive and not transported by EMS Transport to hospital/mode of transport Patient status at ED arrival (ROSC or ongoing resuscitation)
Hospital	
Hospital information:	Date of ED arrival Name of hospital, trauma level Inter-hospital transfer to another acute hospital, date
Outcome:	Date of final ED/hospital disposition Hospital discharge survival status

* Detailed descriptions of both mandatory and optional ROC Trauma Epistry variables are included in Appendix 2.

[†] Although time call received at the initial 9-1-1 dispatch is available at some sites, many other sites have layered dispatch systems where initial calls are relayed from a primary safety access point (i.e., first ring at 9-1-1) to a dedicated EMS dispatch center. Based on uniform availability, EMS time zero in the ROC Epistry; Cardiac Arrest represents the time of call to the EMS dispatch center.

Table 4**Cardiopulmonary Resuscitation Process Variables**

Variable	Definition
Ventilations	The number of ventilations counted for a minute or for the portion of the minute for which the signal could be analyzed. Calculation by hand or by software (and verified by reviewer) for number of ventilations delivered.
Chest compressions	The number of compressions counted per minute. Calculated by hand or by software (and verified by reviewer) of the number of compression delivered.
Compression rate	The median rate at which chest compressions were performed during a series of chest compressions. Calculations by hand or software (and verified by reviewer) for the rate of 2 or more compressions separated by less than 1–2 seconds between compressions.
CPR fraction	Defined as $+(Total\ seconds\ with\ chest\ compressions) \div (Total\ seconds\ with\ interpretable\ signal\ and\ no\ evidence\ of\ spontaneous\ circulation)$. Report the value calculated/documentated by the manufacturer software.
Compression depth (optional)	For those machines capable of reporting compression depth in cm.
Compression release (optional)	For those machines capable of reporting the number of compressions with incomplete release (as assessed by the device) on the upswing of the compression
Peak ETCO ₂ (optional)	For those sites that have continuous end tidal CO ₂ levels reported as part of the electronic download indicate the average CO ₂ level over 60 seconds
Capnography ventilations and #seconds missing (optional)	For those sites that have continuous end tidal CO ₂ levels, indicate the number of seconds in a minute (0–60) for which capnography signal was interrupted. If #seconds missing is 60, then no data should be entered for 'capnography ventilations'