Resuscitation 115 (2017) 129–134

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Effects of bystander CPR following out-of-hospital cardiac arrest on hospital costs and long-term survival☆

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ARTICLE INFO

Article history:
Received 7 February 2017
Received in revised form 30 March 2017
Accepted 13 April 2017

Keywords:
Out-of-hospital cardiac arrest
Bystander CPR
Costs
Long-term mortality

ABSTRACT

Background: Bystander cardiopulmonary resuscitation (CPR) is associated with a greater likelihood of survival to hospital discharge after out-of-hospital cardiac arrest (OHCA). However the long-term survival benefits in relationship to cost have not been well-studied. We evaluated bystander CPR, hospital-based costs, and long-term survival following OHCA in order to assess the potential cost-effectiveness of bystander CPR.
Patients and methods: We conducted a retrospective cohort study of consecutive EMS-treated OHCA patients >= 12 years who arrested prior to EMS arrival and outside a nursing facility between 2001 and 2010 in greater King County, WA. Utstein-style information was obtained from the EMS registry, including 5-year survival. Costs from the OHCA hospitalization were obtained from the Washington State Comprehensive Hospital Abstract Reporting System. Cost effectiveness was based on hospital costs divided by quality-adjusted life years (QALYs) for a 5-year follow-up window.
Results: Of the 4448 eligible patients, 18.5% (n = 824) were discharged alive from hospital and 12.1% (n = 539) were alive at 5 years. Five-year survival was higher in patients who received bystander CPR (14.3% *vs.* 8.7%, p < 0.001) translating to an average 0.09 QALYs associated with bystander CPR. The average (SD) total cost of the initial acute care hospitalization was USD 19,961 (40,498) for all admitted patients and USD 75,175 (52,276) for patients alive at year 5. The incremental cost-effectiveness ratio associated with bystander CPR was USD 48,044 per QALY.
Conclusion: Based on this population-based investigation, bystander CPR was positively associated with long-term survival and appears cost-effective.

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Background

Bystander cardiopulmonary resuscitation (CPR) is the cornerstone of successful resuscitation following out-of-hospital cardiac arrest (OHCA) [1]. Moreover, evidence indicates that the quality of CPR can influence the likelihood of meaningful survival [2]. A worthwhile goal is to increase the frequency and quality of bystander CPR to improve public health. However, these efforts require resources. Although different programs are not mutually exclusive, stakeholders may need to determine how they support bystander CPR initiatives in the context of early access automated external defibrillation (public, police, first responder), EMS training and quality improvement, and hospital care.

One useful consideration to inform resource allocation is to understand the value of the therapy. Indeed experts recommend taking costs into consideration when evaluating interventions to improve OHCA management [3]. In this investigation, we use information from a regional OHCA registry and a database of hospital costs to assess the association of bystander CPR with long-term survival and the cost of the incident OHCA hospitalization in order to estimate the cost effectiveness of bystander CPR [4–9].

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at 10.1016/j.resuscitation.2017.04.016.

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http://dx.doi.org/10.1016/j.resuscitation.2017.04.016
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Methods

Study design, population, and setting

The investigation was a retrospective cohort study of persons > = 12 years who suffered non-traumatic (medical) OHCA outside a nursing facility prior to EMS arrival who received full EMS resuscitation (Basic Life Support and Advanced Life Support) between January 1, 2001 and December 31, 2010 in greater King County, WA. The definition of cardiac arrest requires that a patient receive EMS CPR and/or shock with a public access AED. We excluded arrests that occurred in nursing facilities because we wished to focus on a non-institutionalized patient population that might be expected to benefit from OHCA resuscitation efforts such as bystander CPR.

Greater King County, Washington has a population of approximately 1.3 million persons who live in an approximately 2000 square mile urban, suburban, and rural setting. Citizens access emergency care by calling 9-1-1 where trained telecommunicators identify potential OHCA and coach CPR if indicated. The region is served by a two-tier EMS response system with 28 fire department-based Basic Life Support (BLS) agencies and 5 Paramedic Advanced Life Support (ALS) agencies that follow the American Heart Association resuscitation guidelines. Median response intervals for BLS and ALS crews are 5 and 9 min, respectively.

Clinical data and Bystander CPR

Information related to patient characteristics, resuscitation circumstances, and clinical outcomes were obtained from the regional OHCA registry that is organized according to the Utstein template [10]. Data resources for the registry are abstracted from the dispatch recording, EMS reports, electronic defibrillator recording, hospital records, and vital statistic records from the State Department of Health. Bystander CPR was defined as the provision of CPR by anyone prior to EMS arrival. Ascertainment of bystander CPR is through review of the EMS report and the dispatch recording of the 9-1-1 call.

Hospital cost

A cost analysis was conducted from the provider perspective, and focused on inpatient hospital cost. All patients in the study population received full EMS resuscitation, so we can assume that their prehospital costs were the same or not associated with bystander CPR. Hospital charges were obtained from the Washington State Comprehensive Hospital Abstract Reporting System (CHARS). The CHARS data include hospital charges, International Classification of Diseases (ICD-9) codes for diagnoses and procedures, length of stay, and patient disposition information. Only the hospitalizations directly related to the acute phase of care following OHCA were used to sum the total hospital charges. Consecutive CHARS hospital admission records without gaps in discharge and subsequent admit dates were included until the patient expired in hospital or was discharged alive.

Of the 1802 patients who survived to hospital admission, 1755 (97.4%) were linked to a CHARS hospital record for the incident OHCA event. Of the 1755 linked cases, 1532 had one hospital admit record, 221 transferred to a second hospital during their post-cardiac arrest treatment, and 2 patients transferred among 3 hospitals. The reasons for hospital transfer during acute-care phase typically involved advanced treatments such as implantable defibrillator placement or coronary artery bypass grafting. Hospital costs were summed across the multiple records for patients who transferred between hospitals.

In the US healthcare system, charges are the total dollars billed by the hospital and costs are the total amount received by the hospital from payers such as Medicare, private insurance, and patients. Hospital charges can differ substantially from costs. We estimated costs using the cost-to-charge ratio provided by the Washington State Department of Health by multiplying total charges for each hospitalization by the hospital-specific all-payer inpatient cost/charge ratio for each year. Cost data were converted to comparable 2010 dollars to adjust for inflation by multiplying the cost from a given year by the ratio of December 2010 Consumer Price Index for hospital services to the same Consumer Price Index for December of the given year [11].

Clinical outcomes

The main clinical outcome was quality-adjusted life years (QALYs) derived from vital status during follow-up censored at 5 years post discharge or at the time of death. Survival was censored at 5 years as this enabled comprehensive ascertainment of vital status for the cohort. Survival following discharge was determined by a match with the Washington State Vital Records, the National Social Security Death Index, or publicly available web-based sources [12]. In order to generate QALYs, individual life-years were discounted according to a quality-of-life multiplier. Based on prior reports, a good neurological outcome defined by a Cerebral Performance Categories scale of 1 or 2 was assigned a multiplier of 0.75, and a poor neurological outcome defined by a Cerebral Performance Categories scale score of 3 or 4 was assigned a weight of 0.39 [13,14]. Secondary outcomes included survival to hospital admission, survival to hospital discharge, and 5-year survival.

Statistical analysis

We used descriptive statistics to characterize the cohort overall and according to bystander CPR status. To inform the two-part model approach to cost and QALY estimates (described below), we used multivariable logistic regression to determine the association of bystander CPR with hospital admission, hospital discharge, and 5-year survival. The model adjusted for the upstream Utstein variables of age (continuous), EMS response time (continuous), gender, presence of witness, location of arrest, and cardiac etiology (yes or no). We a-priori chose not to stratify these results on the initial rhythm or hospital care because these characteristics are potentially downstream pathway of bystander CPR.

Analysis of costs

We analyzed cost using a 2-part model where the first part estimates survival to hospital admission, and the second part estimates the costs among patients admitted to hospital [15–18]. In the first part, we estimated the association between bystander CPR and odds of survival to hospital admission, which is identical to incurring hospital costs, using the multivariable logistic regression described above. Patients who died prior to hospital admission did not generate differential hospital cost related to bystander CPR. In the second part, we estimated the conditional effect of bystander CPR on hospital costs among patients who survived to hospital admission. The results of parts one and two are multiplied to estimate the unconditional effect of bystander CPR on costs.

Analysis of QALYs

We also analyzed QALYs using the 2-part model where the first part estimates survival to hospital discharge, and the second part estimates the QALYs among survivors. In the first part, we estimated the association between bystander CPR and the odds of survival to hospital discharge, which is necessary to benefit substantially from improved mortality and/or morbidity, using the

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