Resuscitation 90 (2015) 143–149

Contents lists available at ScienceDirect

Resuscitation

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

Clinical Paper

The survival benefit of dual dispatch of EMS and fire-fighters in out-of-hospital cardiac arrest may differ depending on population density – A prospective cohort study☆

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ARTICLE INFO

Article history:
Received 26 August 2014
Received in revised form 2 February 2015
Accepted 22 February 2015

Keywords:
Out-of-hospital cardiac arrest
Cardiopulmonary resuscitation
Dual dispatch
Population density

ABSTRACT

Background: Outcome after out-of-hospital cardiac arrest (OHCA) varies between contexts. Dual dispatching of fire-fighters or police in addition to emergency medical services (EMS) has the potential to increase survival, but the effect in urban vs. rural areas is unknown. The aim of this study was to determine the effects of dual dispatching on response times and outcome in regions with different population density.
Methods and results: The study design was a prospective cohort study of EMS-treated OHCAs from 2004 (historical controls, only EMS dispatch) and 2006–2009 (intervention, dual dispatch of EMS and fire-fighters), with data on exact geographical coordinates.

Patients were divided into four subgroups depending on population density: rural (<250 persons/km^2), suburban (250–2999/km^2), urban (3000–5999/km^2) and downtown (≥6000/km^2).

Totally, 2513 OHCAs were included (historical controls, $n = 571$ and intervention, $n = 1942$). Median time to arrival of first unit shortened significantly in all subgroups, ranging from 0.8 to 3.2 min, with the main time gain in the rural area.

There were significant differences in 30-day survival between the historical controls vs. the intervention group in the suburban population (3.1% vs. 7.0%, $p = 0.02$) and in downtown (4.1 vs. 14.6, $p = 0.04$). In the urban population the difference was 2.7 vs. 6.9% ($p = 0.06$) and in the rural population (4.7 vs. 5.3, $p = 0.82$).
Conclusions: Dual dispatch of fire-fighters and EMS in OHCA significantly reduced response times in all studied regions. The 30-day survival increased significantly in the downtown and suburban populations, while a limited impact was seen in the rural areas.

1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a major public health concern, affecting 300,000 victims per year in Europe, with a mortality rate of almost 90%.[1] The incidence of OHCA and its outcome vary substantially between countries and within different regions in a nation.[1–6]

In observational studies population density has been demonstrated to be an independent factor predicting survival rates.[7–9] Longer call–response intervals, higher rates of bystander cardiopulmonary resuscitation (CPR) and lower rates of cardiac origin have previously been observed in sparsely populated regions.[4,7]

The dispatch of CPR-trained fire-fighters or policemen equipped with automated external defibrillators (AEDs) in addition to the emergency medical services (EMS) in cases of OHCA has been shown to reduce time intervals and in some studies, improve outcome in patients with ventricular fibrillation (VF) as first rhythm.[10–13] Besides the earlier initiation of quality CPR and defibrillation, the reduced response times also may lead to that more patients can be reached when they are in a shockable rhythm.

Most of these studies have been performed in urban or suburban areas. Whether or not the introduction of a large dual dispatch programme has positive effects on survival rates in both highly populated areas as well as sparsely populated areas in a specific region, such as the greater Stockholm area, is, however, unknown. We have recently published data on short and long term survival after

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2015.02.036.

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http://dx.doi.org/10.1016/j.resuscitation.2015.02.036
0300-9572/

the implementation of a dual dispatch system using fire-fighters as first responders improved outcome in witnessed OHCA in the greater Stockholm area, with over 2 million inhabitants in a region of 6519 km^2.[14]

The aim of this predefined substudy was to determine the effects of a dual dispatch system in OHCA on response time and 30-day survival in regions with different population density.

2. Methods

The study was performed in the greater Stockholm area (see Fig. 1), with a population of 2,019,182 inhabitants (31st of December 2009), of which 50.6% were women and 14.7% were persons over 65 years of age.[15] The study was conducted between the 1st of January 2004 and the 31st of December 2009 and was approved by the Regional Ethics Committee (registration number 2005/423-31, 2010/1835-32).

This study is a predefined substudy on the effect of dual dispatch in OHCA in regions with different population density. The study design is prospective cohort study where the effect of the interventions was compared with historical controls.

2.1. Study groups – population divided on the basis of population density

The patients were divided into four subgroups depending on the population density of the area in which OHCA occurred. Cut-off values for population densities were as follows and the groups were classified as:

1. Rural (<250/km^2).
2. Suburban (250–2999/km^2),
3. Urban (3000–5999/km^2),
4. Downtown (≥6000/km^2).

2.2. Study area

The distribution of the fire stations within the different study groups is seen in Fig. 1. The rural group covered 5415 km^2 and 294,289 inhabitants, the suburban group covered 1105 km^2 and 937,926 inhabitants, the urban group covered 149 km^2 and 565,354 inhabitants and the downtown group covered 18 km^2 and 257,424 inhabitants (Fig. 1).

2.3. Geographical information on OHCA

The Geographical Information System (GIS) is a computer-based system used to integrate and analyse geographical data. In this study the "join attribute by location" function in Quantum GIS version 1.8.0 was used.[16] A parish is the smallest administrative area in which there are relevant files in Sweden. In this study, the digital spatial data obtained from the Emergency Dispatch Centre was used to locate the parish in which each OHCA had occurred. Subsequently, the cardiac arrest data was merged with the spatial data so as to be able to perform the analyses.

The population density data for each parish (n = 100) in the greater Stockholm area was collected from Statistics Sweden. Stockholm is situated on several islands and for each parish adjustments were made for the land/water area ratio. The spatial vector data was downloaded from Lantmäteriet,[17] which have maps of all administrative areas in Sweden.

2.4. Emergency medical services and introduction of dual dispatch with first responders

The EMS system in Stockholm is two-tiered, with an advanced life support level as the second tier (e.g. nurses specialised in anaesthesia, or an anaesthesiologist).

The dual dispatch programme concerning OHCA was implemented in 2005, a year that was predefined as a run-in period. In cases of suspected OHCA, the dispatcher alerted the nearest available EMS and thereafter deployed the closest available fire department by using a computer-mediated alarm code. The dispatch of fire-fighters was intended to happen simultaneously with EMS dispatch. The dual dispatch procedure has been described previously.[13]

In the greater Stockholm area all the 43 fire stations were equipped with AEDs (Fig. 1). Fire-fighters underwent an 8-hour course in CPR and in the use of AEDs according to European Resuscitation Council (ERC) guidelines.[18] The training programme was repeated once a year. In 2007, one police precinct in Stockholm city joined the project and police vehicles were dispatched in a defined area in the city centre.

Thus, resuscitation attempts followed ERC guidelines. In cases where fire-fighters arrived first, they were responsible for medical assessment. If the patient was unresponsive and pulse-less, fire-fighters started CPR and attached the AED. Ventilation by fire-fighters was performed by using a mouth-to-mouth resuscitation mask. On arrival, the EMS took over responsibility for treatment.

2.5. Patients

Inclusion criteria were EMS-treated OHCA patients from 2004 (historical control group, where only EMS were dispatched) and 2006–2009 (intervention group, with dual dispatching of EMS and fire-fighters). The main reason for not extending the control period further (i.e. also include patients before 2004) was to ensure similar in-hospital treatment strategies for both patient groups (intervention and historical controls). In 2002–2003 a significant shift in the in-hospital treatment occurred with the implementation of therapeutic hypothermia and also increased use of immediate coronary angiography.

Exclusion criteria were age ≤8 years, EMS crew-witnessed OHCA, in-hospital cardiac arrests, cases were EMS crew did not start CPR for ethical reasons (i.e. terminal disease and existing Do Not Attempt to Resuscitate orders, or obvious signs of death), cardiac arrests caused by trauma and cases of OHCA where data on the geographical coordinates of the place concerned could not be obtained.

2.6. Data collection

The characteristics of the case (i.e. age, location of the arrest, witnessed status, if bystander CPR was performed, presumed cause of the arrest and first recorded rhythm), the treatment given by EMS and the outcome data (i.e. if patients were admitted alive at hospital and 30-day survival) were collected from the Swedish Cardiac Arrest Register (SCAR) to which the EMS crew reported, according to the Utstein template.[19] SCAR is a national quality register funded by the Swedish National Board of Health and Welfare. The register is run by the Swedish Resuscitation Council and covers all EMS organisations in Sweden.[20] Event times, such as call to dispatch centre, dispatch and arrival of first responders and exact geographical x and y coordinates of the place of cardiac arrest were collected from the Emergency Dispatch Centre database.