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Clinical paper

Long-term mortality and morbidity among 30-day survivors after in-hospital cardiac arrests - a Swedish cohort study

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ABSTRACT

Objectives: Resuscitation on in-hospital cardiac arrest (IHCA) is estimated to occur in 200,000 hospitalised patients annually in the US and short-term survival, i.e. 30 days, is reported to be around 15–20%. Even if 30-day survival is a good measure of successful resuscitation, the number of survivors is quite high and a perspective on longer-term outcomes is relevant.
Aim: To assess long-term mortality among 30-day survivors after an IHCA.
Material and methods: All patients ≥18 years surviving for at least 30 days after an IHCA at Karolinska University Hospital between 1st January 2007 and 31st December 2014 were included. Data regarding the IHCA, patient characteristics, new cardiac, pulmonary or neurological diagnosis and death dates were obtained from complete Swedish national registries. Censor date was set as 10th February 2017. Differences in long-term survival between those with shockable compared to those with non-shockable first rhythm were assessed with Kaplan Meier survival curves, with adjustment for age-adjusted Charlson Co-morbidity Index (ACCI).
Results: In all, 1019 patients suffered an IHCA, of whom 267 (26%) survived for at least 30 days. Out of the 267 patients, 158 (59%) were still alive at the censor date, i.e. 3–10 years after their IHCA. There was a significant better long-term survival among those with shockable initial rhythm than those with a non-shockable first rhythm that persisted after adjustment for ACCI (adjusted 10-year survival; >75% and >50% respectively, p-value <0.01).
Conclusion: In conclusion, long-term survival after an IHCA is quite good irrespective of initial rhythm but is related to the burden of baseline co-morbidities.

Introduction

Resuscitation on in-hospital cardiac arrests (IHCA) is estimated to occur in 200,000 hospitalised patients annually in the US and about 2700 IHCAs are reported yearly in Sweden [1,2]. Short-term survival, i.e. 30 days, is reported to be around 15–20% in the US [3] and about 28% in Sweden [2]. Even if 30-day survival is a good measure of a successful resuscitation, the number of survivors is quite high and a perspective on longer-term outcomes is relevant. One recent study from the US by Feingold et al. showed that the risk of death is higher among 30-day survivors after IHCA compared to matched controls, and that the highest risk for deaths is within the first 90 days [3]. Except for Feingold et al.'s study, long-term studies on both mortality and morbidity are sparse.

A cardiac arrest affects the heart, lungs and brain which is why much focus in the early post-arrest phase is to resuscitate these specific organ systems [4]. Further, it has been estimated that most cardiac arrests are derived from cardiac causes, especially if the first rhythm is shockable [5]. In contrast, non-shockable rhythms often originate in more heterogeneous aetiologies, such as hypoxia, hypovolemia, hypo/hyperkalaemia, hypothermia, thrombosis/pulmonary embolus, cardiac tamponade, tension pneumothorax and intoxication [6]. However, to date no studies on long-term follow-up regarding new diagnoses from the core systems heart, lung and brain exists. Therefore, our aim was to perform a long-term, i.e. at least 3 years, follow-up of IHCA survivors regarding overall mortality and new cardiac, pulmonary

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and neurological morbidity in patients with shockable compared to non-shockable initial rhythm.

Method

Study design

This registry-based cohort study used the Swedish Registry for Cardio-Pulmonary Resuscitation (SRCR) as the main source to identify all IHCAs at Karolinska University Hospital between 1st January 2007 and 31st December 2013.

Settings

Karolinska University Hospital is in Stockholm, home to approximately 2,000,000 people. Karolinska is one of five large hospitals and has two equally sized sites 30 km apart; Solna and Huddinge. The Solna site is a level one trauma unit, has neuro and thoracic surgery units and provides 24/7 angiography for ST-elevation myocardial infarctions. The Huddinge site includes a geriatric ward and relatively fewer intensive care unit (ICU) beds. Karolinska has about 1300 beds, 108,000 admissions yearly and 1.8 million patient visits.

Ethics

All patients surviving their IHCA were asked six months afterwards for informed consent and agreed to participate in the Swedish Registry for Cardio-Pulmonary Resuscitation (SRCR) and on-going studies based on it. The Regional Ethical Review Board in Stockholm, Sweden approved the study, Dnr 2016/2216-31/2.

Participants

The SRCR [2] collect data according to Utstein [7] and define IHCA as *"a hospitalised patient who is unresponsive with apnoea (or agonal, gasping respiration) where CPR and/or defibrillation have been initiated*." The inclusion criteria were all adult patients surviving for at least 30 days after an IHCA occurring from January 1 st 2007 and onwards until the end date of December 31th 2013. The end date was set to gather information regarding long-term morbidity under at least 3 years after the IHCA. No patients or location of the IHCA were excluded. In the case of multiple IHCAs, only the first event per year was included.

Long-term morbidity and mortality

Information on the outcome, i.e. long-term morbidity and mortality was retrieved through the electronic patient record. Morbidity was a priori defined as new ICD-10 codes after the IHCA within the categories cardiac (I10-3, I15, I20, I22, I25, I37, I44-45, I47-52, I65, I67, I70-71, I74, I79, Z95), pulmonary (J40-45, J47, J81, J96) and neurological (G80-82, F03.9, I61-4, I69).

The censor date for new morbidities as well as time to death was set as February 10th 2017. The electronic patient record is linked to the Swedish total population registry and automatically updated within a maximum delay of three days, which enables a national all-encompassing complete follow-up [8].

Data collection and categorisation

Patients were identified through the hospital's cardiac arrest report sheet, where data on the following variables were collected: sex, age (collected in years, categorised into 10-year intervals according to the age-adjusted Charlson Co-morbidity Index (ACCI) [9] starting at 18–50, 51–60 and further on to >81 years), location of IHCA (patient ward, intermediate care unit, intensive care unit (ICU), angio lab/operating theatre or other area including emergency department and radiology department), and first documented heart rhythm (shockable, i.e. VT/VF or non-shockable i.e. PEA/asystole). Thereafter by entering the hospital's electronic patient record (Take Care version 14.2.9) information on co-morbidities was gathered based on ICD-10 codes available at least at admission to the hospital and assessed according to the ACCI [9–12]. The ACCI is a weighted score of co-morbidities based on the relative risk of one-year mortality that has previously been used in IHCA [9,10] and was categorised into "*No burden of ACCI*" if the ACCI was 0 points, "*Low burden of ACCI*" if the ACCI was 1–2 points, "*Moderate burden of ACCI*" if the ACCI was 3–5 points, and "*High of ACCI*" if the ACCI was at least 6 points.

Statistical analyses

Characteristics of patients surviving at least 30 days were presented and frequency counts for survival ratios for each included year were performed. Differences in long-term survival between those with shockable compared to those with non-shockable first rhythm were assessed with Kaplan Meier survival curves, and adjustment was carried out for ACCI category. Similarly, Kaplan Meier survival curves were drawn for ACCI categories with adjustment for first rhythm. Differences in long-term survival were assessed with two-sided log-rank test and a p-value of $\leq$0.05 was interpreted as statistically significant. Differences in the portion of patients with new morbidities among those with shockable initial rhythm compared to those with non-shockable rhythm were compared using the two-sided Chi2 test and a p-value of $\leq$0.05 was interpreted as statistically significant. Missing data was kept missing, i.e. not imputed or estimated. All analyses were performed with the statistical package STATA 10.2 for Windows (STATA Corp, College Station, TX).

Results

Characteristics of the 30-day survivors

In all, 1019 patients suffered an IHCA at Karolinska during 2007–2013 and in total 267 (26%) survived for at least 30 days. Among the 267 survivors, two thirds were men and at the time of the IHCA two thirds were aged below 70 years, and 43% had no or low burden of co-morbidities according to the *Acc*I (Table 1).

In terms of the location of IHCA, a quarter suffered their IHCA on a patient ward, another quarter in a high dependency unit and approximately 13% each suffered their IHCA in an intensive care unit, emergency department or angiographic catheter lab. About 70% were under ECG-surveillance and almost all (94%) were witnessed. Regarding the first documented heart rhythm, about half had an initially shockable rhythm (Table 1). There were no significant differences regarding sex, ACCI, ECG surveillance or witnessed between those with shockable compared to non-shockable rhythm (data not shown).

Long-term mortality

Out of the 267 patients surviving for at least 30 days after their IHCA, 158 (59%) were still alive at the censor date 10th February 2017, i.e. 3–10 years after their IHCA (median follow-up time 1543 days, interquartile range 876–2223, Fig. 1).

There was significantly better long-term survival among those with shockable initial rhythm than those with a non-shockable first rhythm that persisted after adjustment for ACCI (adjusted