Resuscitation xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Resuscitation

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

Clinical paper

Outcomes and healthcare-associated costs one year after intensive care-treated cardiac arrest☆

Ilmar Efendijev[a,*], Daniel Folger[a], Rahul Raj[b], Matti Reinikainen[c], Pirkka T. Pekkarinen[a], Erik Litonius[a], Markus B. Skrifvars[a,d]

[a] University of Helsinki and Helsinki University Hospital, Division of Intensive Care Medicine, Department of Anaesthesiology, Intensive Care and Pain Medicine, Helsinki, Finland
[b] University of Helsinki and Helsinki University Hospital, Department of Neurosurgery, Helsinki, Finland
[c] North Karelia Central Hospital, Department of Intensive Care, Joensuu, Finland
[d] University of Helsinki and Helsinki University Hospital, Department of Emergency Care and Services, Helsinki, Finland

ARTICLE INFO

Keywords:
Cardiac arrest
Survival
Outcome
Long-term outcome
Neurological outcome
Healthcare costs
Cost-effectiveness

ABSTRACT

Background: Despite the significant socioeconomic burden associated with cardiac arrest (CA), data on CA patients' long-term outcome and healthcare-associated costs are limited. The aim of this study was to determine one-year survival, neurological outcome and healthcare-associated costs for ICU-treated CA patients.
Methods: This is a single-centre retrospective study on adult CA patients treated in Finnish tertiary hospital's ICUs between 2005 and 2013. Patients' personal identification number was used to crosslink data between several nationwide databases in order to obtain data on one-year survival, neurological outcome, and healthcare-associated costs. Healthcare-associated costs were calculated for every patient stratified by cardiac arrest location (OHCA = out-of-hospital cardiac arrest, IHCA = all in-hospital cardiac arrest, ICU-CA = in-ICU cardiac arrest) and initial cardiac rhythm. Cost-effectiveness was estimated by dividing total healthcare-associated costs for all patients from the respective group by the number of survivors and survivors with favourable neurological outcome.
Results: The study population included 1,024 ICU-treated CA patients. The sum of costs for all patients was €50,847,540. At one-year after CA, 58% of OHCAs, 44% of IHCAs, and 39% of ICU-CAs were alive. Of one-year survivors 97% of OHCAs, 88% of IHCAs, and 93% of ICU-CAs had favourable neurological outcome. Effective cost per one-year survivor was €76,212 for OHCAs, €144,168 for IHCAs, and €239,468 for ICU-CAs. Effective cost per one-year survivor with favourable neurological outcome was €81,196 for OHCAs, €164,442 for IHCAs, and €257,207 for ICU-CAs.
Conclusions: In-ICU CA patients had the lowest one-year survival with the effective cost per survivor three times higher than for OHCAs.

Introduction

Cardiac arrest (CA) remains an important cause of morbidity and mortality [1]. Despite numerous researches on CA, data on CA-related healthcare costs are still scarce [2]. However, with an estimated 350,000–700,000 sudden CA events yearly in Europe alone, no doubt exists that CA has significant socioeconomic consequences [3,4]. Accurate quantification of cardiac arrest-related healthcare costs is important, as it can facilitate management and allocation of available resources in order to improve post-CA outcomes through better prevention and treatment strategies.

In this study, we determined one-year healthcare-associated costs and outcomes in post-CA patients treated in intensive care units (ICU) of a tertiary hospital, focusing on the impact of CA location and initial cardiac rhythm on costs and outcomes.

Methods and materials

Setting and population

This retrospective study was conducted at Meilahti Hospital, Helsinki, Finland, which serves as the primary referral centre for CA

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at https://doi.org/10.1016/j.resuscitation.2018.06.028.

* Corresponding author at: Department of Anaesthesiology and Intensive Care Medicine, Helsinki University Hospital, Haartmaninkatu 4, PL 340, 00029 HUS, Helsinki, Finland.
E-mail address: ilmar.efendijev@hus.fi (I. Efendijev).

https://doi.org/10.1016/j.resuscitation.2018.06.028
Received 25 March 2018; Received in revised form 15 June 2018; Accepted 25 June 2018

patients in the Helsinki and Uusimaa region, with a population of approximately 1.6 million people (30% of the total Finnish population). Using the Finnish Intensive Care Consortium (FICC) database [5], we identified adult CA patients (age ≥18 years) treated in Meilahti Hospital's ICUs from January 1, 2005, to December 31, 2013. Only the first cardiac arrest event was considered. Electronic health records (EHR) of individual patients were reviewed for relevant data. Patients with missing or incomplete data were excluded from the analyses. The study was approved by the ethics committee of the Operative Division of Helsinki University Hospital (June 2014: 194/13/03/02/2014 TMK02 §97), the Finnish National Institute for Health and Welfare (May 2014: THL/713/5.05.01/2014), Statistics Finland (May 2014: TK-53-1047-14), the Social Insurance Institution (September 2015: Kela 55/522/2015) and the Office of the Data Protection Ombudsman (February 2016: 2794/204/2015).

Extracted variables and data sources

The FICC database provided data on hospital survival, preadmission physical status (a modified World Health Organisation/Eastern Cooperative Oncology Group [WHO/ECOG] classification implemented by FICC), mean daily Therapeutic Intervention Scoring System (TISS-76) score and its components for the whole ICU stay, Simplified Acute Physiology Score II (SAPS II) and Acute Physiology and Chronic Health Evaluation II (APACHE II) components and scores [6–10]. To obtain the confirmed date of death, we linked the patients' unique personal identification numbers with the Finnish Population Register Centre database, which registers all deaths of Finnish residents. From the hospital's EHR, we gathered detailed information regarding time of CA, time to return of spontaneous circulation (ROSC), initial cardiac rhythm, CA location and cerebral performance category (CPC) for survivors at one year after CA [11–13]. Good neurological outcome was defined as CPC scores 1–2, and poor neurological outcome as CPC scores 3–4 [12,14].

Healthcare-associated costs

Total one-year healthcare-associated costs included three parameters: hospital costs, rehabilitation costs and social security costs. Hospital costs were retrieved from the hospital's billing records. These costs were for the entire treatment period, including, e.g. personnel, surgery, diagnostics, ICU stay, and ward stay. Rehabilitation costs were calculated by multiplying the length of stay in the rehabilitation unit with the average price per day for the respective level of care unit [15]. Social security costs were obtained from the national Social Insurance Institution. All reimbursements made by the Social Insurance Institution, up to one-year after the admission, were obtained and summed. These costs covered disability allowances, sickness allowances, private physician and physiotherapist expenses, prescription drug expenses and medical transport expenses.

Cost data analysis included calculation of mean healthcare costs for hospital survivors, hospital non-survivors, one-year survivors and hospital survivors who failed to survive to one year after CA. Mean costs were calculated as the sum of total costs of the appropriate patient group divided by the number of individuals in the same group. To estimate cost-effectiveness, we calculated the effective cost per survivor (ECPS) and the effective cost per survivor with favourable neurological outcome (ECPFN). The ECPS and ECPFN were calculated as the sum of total costs for all patients divided by the number of survivors and by the number of survivors with favourable neurological outcome, respectively [16].

We adjusted all costs according to the consumer price index (CPI) in Finland to 2013 euros, using the following formula:

$$CPI\ adjusted\ cost = Cost * \frac{CPI\ in\ 2013}{Admission\ year\ CPI}$$

Statistical analyses

For the statistical analyses, we used SPSS statistics for MAC, version 24.0, released 2016 (IBM Corp, Armonk, NY, USA) and Stata Statistical Software for Mac OS (StataCorp LP, College Station, TX).

We used a chi-square test to compare categorical variables and a Mann-Whitney *U* test or Student's *t*-test for continuous data, as appropriate. To adjust for case-mix differences, we developed a severity-of-illness model based on age, admission year, simplified preadmission physical status (independent vs. non-independent), presence of a severe comorbidity (according to SAPS II and APACHE II), initial cardiac rhythm, time to ROSC and SAPS II score sum without age and comorbidity points. We used logistic regression to assess case-mix adjusted survival and neurological outcome stratified by CA location and multivariate linear regression with CA location as a separate additional variable to estimate the adjusted healthcare costs and treatment intensity for the whole study population and separately for hospital survivors.

Results

Study population

A total of 1,024 patients were eligible for the study (mean 114 patients per year): 66% out-of-hospital cardiac arrests (OHCA) and 34% in-hospital cardiac arrests (IHCA). Table 1 and Fig. 1 summarise the exclusion process and baseline characteristics of the study population. Compared to IHCA, OHCA patients were younger and had better

Table 1
Study population's baseline characteristics.

Variables	OHCA (n = 672)	IHCA (n = 352)	p-value
Age in years, *median (IQR)*	61 (53–69)	64 (56–74)	< 0.05
Male gender, *n (%)*	514 (77)	231 (66)	< 0.05
Simplified preadmission physical status[a]			
independent, *n (%)*	637 (95)	296 (84)	< 0.05
non-independent, *n (%)*	35 (5)	56 (16)	< 0.05
Severe comorbidity at the time of ICU admission, *n (%)*[b]	92 (14)	125 (36)	< 0.05
SAPS II, *median (IQR)*	43 (34–57)	52 (39–68)	< 0.05
APACHE II score, *median (IQR)*	21 (17–29)	27 (19–34)	< 0.05
SOFA score during the first 24 hours, *median (IQR)*	8 (6–10)	10 (8–13)	< 0.05
TISS-76 average daily score, *mean (SD)*	37 (8)	36 (9)	NS
Time to ROSC in minutes, *median (IQR)*	20 (14–25)	7 (3–12)	< 0.05
Initial cardiac rhythm			
ventricular fibrillation/ventricular tachycardia, *n (%)*	504 (75)	116 (33)	< 0.05
pulseless electrical activity	104 (15)	141 (40)	< 0.05
asystole	49 (7)	66 (19)	< 0.05
other/unknown	15 (2)	29 (8)	< 0.05
LOS ICU in days, *median (IQR)*	3 (2–4)	3 (1–6)	NS
LOS hospital in days, *median (IQR)*	10 (4–19)	10 (4–20)	NS
One-year survival, *n (%)*	391 (58)	146 (41)	–
One-year survivors with favourable neurological outcome, *n (%)*	367 (97)	128 (88)	–

OHCA = out-of-hospital cardiac arrest, IHCA = in-hospital cardiac arrest, IQR = interquartile range, ICU = intensive care unit, SD = standard deviation, SAPS = Simplified Acute Physiology Score, APACHE = Acute Physiology and Chronic Health Evaluation, SOFA = Sequential Organ Failure Assessment, TISS-76 = Therapeutic Intervention Scoring System 76, ROSC = return of spontaneous circulation, LOS = length of stay.

[a] A simplified World Health Organization/Eastern Cooperative Oncology Group classification.

[b] Any severe chronic comorbidity according to APACHE II or SAPSII.