HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Intensive care-treated cardiac arrest: A retrospective study on the impact of extended age on mortality, neurological outcome, received treatments and healthcare-associated costs

Ester Holmström
Medicinekandidat
Helsingfors universitet

Helsingfors 11.03.2021
Avhandling
ester.holmstrom@helsinki.fi
Handledare: Markus Skrifvars
HELSINGFORS UNIVERSITET
Medicinska fakulteten

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Sammandrag

Fakultet: Medicinska fakulteten

Utbildningsprogram: Utbildningsprogrammet i medicin

Studieinriktning: Svenskspråkig studieinriktning

Författare: Ester Holmström, Ilmar Efendijev, Rahul Raj, Pirkka T. Pekkarinen, Erik Litonius, Markus B. Skrifvars

Arbetets titel: Intensive care-treated cardiac arrest: A retrospective study on the impact of extended age on mortality, neurological outcome, received treatments and healthcare-associated costs

Arbetets art: Artikel

Månad och år: 03/2021

Sidantal: 25

Nyckelord: Dissertation; Academic; writing

Förvaringsställe: e-thesis

Övriga uppgifter: -

Sammandrag:

Bakgrund: Hjärtattacker är en av de ledande dödsorsakerna internationellt. Detta i kombination med en åldrande befolkning leder till ett ökat behov för forskning kring ålderns effekt på utfall och vård i hjärtattacker. I denna studie delade vi in vårt patientmaterial i två grupper: patienter 75 år och äldre samt patienter yngre än 75 år. Efter detta jämförde vi grupperna i kategorierna vårdintensitet, neurologiskt utfall efter 12 månader, dödlighet samt hälsovårdskostnader.

Metoder: Vårt material inkluderade alla vuxna patienter som vårdades på Mejlans sjukhus intensivvårdsavdelning på grund av hjärtattack åren 2005-2013. Vårdintensitet bedömdes med hjälp av de totala och de dagliga median TISS-76-poängen (Therapeutic intervention scoring system-76). Kostnadseffektiviteten räknades ut genom att dela de totala hälsovårdskostnaderna av alla patienter med mängden patienter som hade ett gott neurologiskt utfall 12 månader efter hjärtattacken. Vi definierade ett gott neurologiskt utfall med hjälp av CPC-skalan (cerebral performance category), där CPC 1–2 bedömdes som ett gott utfall. För att illustrera skillnader i fördelningen av kostnader användes stapeldiagram. Efter detta bedömde vi också med hjälp av logistisk regression olika faktorers samband med ett dåligt neurologiskt utfall och hög mortalitet. Kaplan-Meier kurvor användes för att illustrera skillnaden i mortalitet mellan åldersgrupperna.

Resultat och slutsats: Totalt 1285 patienter inkluderades i studien, 212 (16%) av dessa var 75 år eller äldre. Det var en klar skillnad i behandlingsintensitet mellan åldersgrupperna, vi konstaterade färre vårdinterventioner hos de äldre både i medeltal totalt och dagligen. Här funderade vi i artikeln om detta kunde vara på grund av en aktiv daglig bedömning av situationen och att man snabbare bedömer att äldre inte tjänar på att vårdas aggressivt. Trots detta var den effektiva kostnaden högre för de äldre, vilket implicerar att vården för äldre ännu kan effektiveras och att vi behöver fortsätta utveckla bra verktyg för bedömning

av vilka åldringar som tjänar på en aktiv och intensiv vård. Det neurologiska utfallet var också markant sämre för den äldre åldersgruppen, dock mycket på grund av den höjda mortaliteten. I våra multivariabel-modeller var faktorer som påverkade det neurologiska utfallet samt mortaliteten: ålder, gerasteni, hjärtrytmen, komorbiditeten och tid till spontan blodcirkulation vid återupplivningen. Därmed kan man konstatera att ålder föga överraskande påverkar utfallet efter en hjärtattack, men att det samtidigt också är viktigt att ta i beaktande övriga faktorer som påverkar utfallet.
(376 ord)

Intensive care-treated cardiac arrest: A retrospective study on the impact of extended age on mortality, neurological outcome, received treatments and healthcare-associated costs

Ester Holmström[1], Ilmar Efendijev[2], Rahul Raj[3], Pirkka T. Pekkarinen[2], Erik Litonius[2], Markus B. Skrifvars[1].

1. Department of Emergency Care and Services, University of Helsinki and Helsinki University Hospital, Helsinki, Finland
2. Department of Anaesthesiology, Intensive Care and Pain Medicine, University of Helsinki and Helsinki University Hospital, Helsinki, Finland
3. Department of Neurosurgery, University of Helsinki and Helsinki University Hospital, Helsinki, Finland.

Abstract

Background: Cardiac arrest (CA) is a leading cause of death worldwide. As population ages, the need for research focusing on CA in elderly increases. This study investigated treatment intensity, 12-month neurological outcome, mortality and healthcare-associated costs for patients aged over 75 years treated for CA in an intensive care unit (ICU) of a tertiary hospital.

Methods: This single-centre retrospective study included adult CA patients treated in a Finnish tertiary hospital's ICU between 2005 and 2013. We stratified the study population into two age groups: <75 and ≥75 years. We compared interventions defined by the median daily therapeutic intervention scoring system (TISS-76) between the age groups to find differences in treatment intensity. We calculated cost-effectiveness by dividing the total one-year healthcare-associated costs of all patients by the number of survivors with a favourable neurological outcome. Favourable outcome was defined as a cerebral performance category (CPC) of 1–2 at 12 months after cardiac arrest. Logistic regression analysis was used to identify independent association between age group, mortality and neurological outcome.

Results: This study included a total of 1,285 patients, of which 212 (16%) were ≥75 years of age. Treatment intensity was lower for the elderly compared to the younger group, with median TISS scores of 116 and 147, respectively ($p < 0.001$). The effective cost in euros for patients with a good one-year neurological outcome was €168,000 for the elderly and €120,000 for the younger group. At 12 months after CA 24% of the patients in the elderly group and 47% of the patients in the younger group had a CPC of 1-2 ($p < 0.001$). Age was an independent predictor of mortality (multivariate OR = 3.36, 95% CI:2.21-5.11, $p < 0.001$) and neurological outcome (multivariate OR = 3.27, 95% CI: 2.12-5.03, $p < 0.001$).

Conclusions: The elderly ICU-treated CA patients in this study had worse neurological outcomes, higher mortality and lower cost-effectiveness than younger patients. Further efforts are needed to recognize the tools for assessing which elderly patients benefit from a more aggressive treatment approach in order to improve the cost-effectiveness of post-CA management.

Keywords: Elderly, Cardiac arrest, intensive care unit, critical care, cardiopulmonary resuscitation, OHCA, IHCA, ICUCA

Background

CA is one of the leading causes of death in the developed world [1], with over three million patients affected each year worldwide [2]. This, in addition to a clear increase in patient longevity globally, mandates more research efforts towards care of the elderly post CA [3, 4]. Not unexpectedly, cardiopulmonary resuscitation (CPR) is more commonly initiated in younger patients, and younger patients receive more aggressive treatment by mobile medical teams [4, 5]. Although post-CA mortality increases with age, it has been disputed whether this is due to age in itself or other CA characteristics [6-8]. Pre-arrest comorbidity and CA factors still need more research in order to explain the variability of outcome in CA among elderly [9].

Only a few studies have focused on the post CA treatment of the elderly in the intensive care unit (ICU) while including long-term outcome [3, 10]. The aim of this study is to explore treatment intensity, outcome and healthcare-associated costs of the ICU-treated elderly CA patients treated in a single centre over a 9-year period. We hypothesise that compared with younger patients, the elderly have higher mortality and worse neurological outcome despite high treatment costs and intensity.

Methods

Study design and setting

This retrospective cohort study was conducted at Meilahti Hospital, Helsinki, Finland, which serves as the primary referral centre for CA patients in the Helsinki and Uusimaa region. This region has a population of approximately 1.7 million people (30% of the total Finnish population). Data were extracted from the Finnish Intensive Care Consortium (FICC) database [11] and include adult CA patients (≥18 years of age) treated in the hospital's ICU between January 1, 2005 and December 31, 2013. We reviewed Electronic health records (EHR) of individual patients for relevant data. Patients with incomplete or missing data and patients where return of spontaneous circulation (ROSC) was not achieved were excluded from the analyses. The patients were divided into two age groups for descriptive purposes: <75 (young) and ≥75 years (elderly).

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).

Data collection and extracted variables

The FICC database provided data on hospital survival, preadmission physical status (a modified World Health Organization/Eastern Cooperative Oncology Group (WHO/ECOG) classification implemented by FICC), mean TISS-76 score and its components for the complete ICU stay, and Acute Physiology and Chronic Health Evaluation II (APACHE II) components and scores [12-15]. In this study APACHE II scores were used excluding the points for age. We obtained the confirmed date of death by linking the patients' unique personal identification numbers with the Finnish Population Register Centre database, which registers all deaths of Finnish residents. Detailed information regarding preadmission physical status, time of CA, time to ROSC, initial CA rhythm and location as well as CPC for survivors at one year after CA was collected from the hospital's EHR [16-19]. We determined preadmission functional status by using a simplified WHO/ECOG classification, where "independent" was defined as the patient being independent in self-care and "dependent" was defined as the patient being partly or fully dependent on help in self-care prior to hospital admission. [20]. A favourable neurological outcome was defined as CPC scores of 1–2 and an unfavourable neurological outcome as CPC scores of 3–4 [19].

Healthcare-associated costs

Healthcare-associated costs included three parameters: index hospital costs, rehabilitation costs and social security costs. We obtained hospital costs from the hospital's billing records. These included costs incurred during the entire treatment period, such as costs of personnel, surgery, diagnostics as well as ICU and ward stay. Rehabilitation costs were calculated by multiplying the length of stay (LOS) in the rehabilitation unit with the average cost per day for the respective level of care unit [21]. Social security costs were retrieved from the national Social Insurance Institution. This is a government-based social security and healthcare system. All reimbursements made by the Social Insurance Institution, up to one year after the admission, were obtained and summed. These included disability allowances, sickness allowances, private physician and physiotherapist expenses, prescription drug expenses and medical transport expenses. All costs were converted to euros based on the 2021 currency rate. Cost data analysis included the calculation of median healthcare costs for each age group and separately for the survivors with a favourable neurological outcome in the studied age groups.

Effective cost per survivor with favourable neurological outcome (ECPSFNO) was calculated by dividing the sum of the total cost for all patients within each age group by the number of patients within that group with a favourable neurological outcome (CPC of 1–2) after 12 months [22]. We further stratified costs according to the location of CA (out-of-hospital CA (OHCA), in-hospital CA (IHCA) and in-ICU CA (ICUCA)). A mean of hospital, rehabilitation and social insurance institution costs was separately calculated for each age group.

Statistical analysis

For statistical analyses we used SPSS statistics for MAC, version 25.0, released in 2017 (IBM Corp, Armonk, NY, USA). The baseline characteristics of the study cohort are described using proportions with percentiles for categorical values and medians with interquartile range for continuous variables. We tested group differences with Mann-Whitney U-test or Chi-square test, as appropriate. Logistic regression was used with original data to calculate univariable odds ratios with corresponding 95% confidence intervals regarding impact on mortality and neurological outcome. Significant factors were included in a multivariate regression model to identify independent predictors of unfavourable neurological outcome and mortality. We illustrated the difference in mortality between the two age groups by using Kaplan Meyer survival curves and a clustered bar of cumulative percentages.
Chi-square tests were used on TISS-point distribution to determine if there were significant differences in treatment intensities between the two age groups and if the location of CA (OHCA or IHCA) affected/influenced treatment intensity.

Results

Study population and factors at resuscitation

The study included 1,285 patients, of which 1,073 (84%) were younger than 75 years and 212 (16%) 75 years or older (Table 1). OHCAs were less common among the elderly with an occurrence of 43% compared to 64% in the young group, $p < 0.001$ (Table 1). A number of other differences between the younger and the elderly population were noted: less elderly patients had an independent preadmission functional status (75% vs. 90%, $p < 0.001$), a non-shockable initial CA rhythm was more common (49% vs. 35%, $p < 0.001$), and ROSC was achieved faster among the elderly patients (median of 10 min vs. 16 min, $p < 0.001$).

Table 1. Patients characteristics

	Age <75 (n=1073)	Age ≥75 (n=212)	*p*
Women, % (no.)	281 (26)	70 (33)	0.041
Location of arrest, % (no.)			<0.001
OHCA	64 (691)	43 (92)	
IHCA	27 (286)	46 (97)	
ICUCA	9 (96)	11 (23)	
Women, % (no.)	281 (26)	70 (33)	0.041
Witnessed arrest, % (no.) [1]	935 (87)	193 (91)	0.130
Initial cardiac-arrest rhythm, % (no.)			<0.001
Shockable (VT or VF)	641 (60)	94 (44)	
Non-Shockable (all other rhythms)	378 (35)	104 (49)	
Unknown	54 (5)	14 (6.6)	
Time to ROSC in minutes, median (IQR) [2]	16 (10-23)	10 (5-18)	<0.001
Independent preadmission functional status % (no.)[3]	90 (960)	75 (158)	<0.001

[1] 2% of patients are missing this information
[2] 9,5% of patients are missing this information
[3] 4.7% of patients are missing this information

Treatment intensity & ICU factors

No difference was observed in the APACHE II scores between the elderly and younger patients when points for age where excluded (Table 2). Treatment intensity was lower in the elderly than in the younger age group, with median daily average TISS scores of 34 and 37 for the elderly and younger patients, respectively, $p < 0.001$. The total amount of TISS points was also lower for the elderly (116 vs. 147, $p < 0.001$) (Table 2). In-hospital as well as in-ICU mortality was higher for the elderly group (ICU mortality 33% vs. 18%, $p < 0.001$; hospital mortality 49% vs. 33%, $p < 0.001$). The ICU LOS was shorter for the elderly than for the younger patients (Table 2). The ICU LOS among the survivors was however not different. Table 2 details the ICU factors, in-hospital mortality, TISS-point distribution and the difference in the selected treatments received at the hospital. TISS-point distribution can be viewed in more detail in the supplementary material (Additional file 1–3).

Table 2. Intensive care unit-factors

	Age <75 (n=1073)	Age ≥75 (n=212)	*p*
APACHE II-score excluding age points, median (IQR)	20 (15-27)	22 (15-27)	0.181
TISS-Score, median (IQR)			
Daily average	37 (31-43)	34 (28-41)	<0.001
Total TISS-score	147 (93-227)	116 (65-192)	<0.001
Treatments received, no. (%)			
Controlled ventilation with or without PEEP	1055 (98)	197 (93)	<0.001
Induced hypothermia	450 (42)	34 (16)	<0.001
Vasoactive drug infusion (> 1 drug)	503 (47)	80 (38)	0.015
Continous antiarrhythmia infusions	212 (20)	35 (17)	0.273
Rx of seizures	140 (13)	13 (6)	0.004
Hemodialysis in unstable patient	18 (2)	8 (4)	0.048
Arterial line	1071 (100)	211 (100)	0.432
In-hospital mortality %(no.)			
Dead in ICU	18 (194)	33 (69)	<0.001
Dead in hospital	33 (357)	49(104)	<0.001
Length of stay in days, median (IQR)			
ICU	3 (2-5)	2 (1-4)	<0.001
Hospital	10 (4-20)	8 (3-16)	0.003
Length of stay in days among patients discharged alive, median (IQR)			
ICU	3 (2-6)	3 (2-6)	0.085
Hospital	14 (8-24)	14 (8-23)	0.654

Healthcare-associated costs

The ECPSFNO was €168,000 and €120,000 for the elderly and young group, respectively. The effective cost for the elderly patient group was higher than that for the younger patient group in all locations of CA except for ICUCA, where it was €173,000 and €308,000, respectively. The elderly patient group received less median funding from the Social Insurance Institution, €714 compared to €1,670 in the younger age group (Table 3, Figure 1, Additional file 4). Median rehabilitation costs were higher for the elderly patient group when we only included those with a favourable 12-month neurological outcome, 5,700 compared to 2,000 ($p = 0.012$) (Table 3).

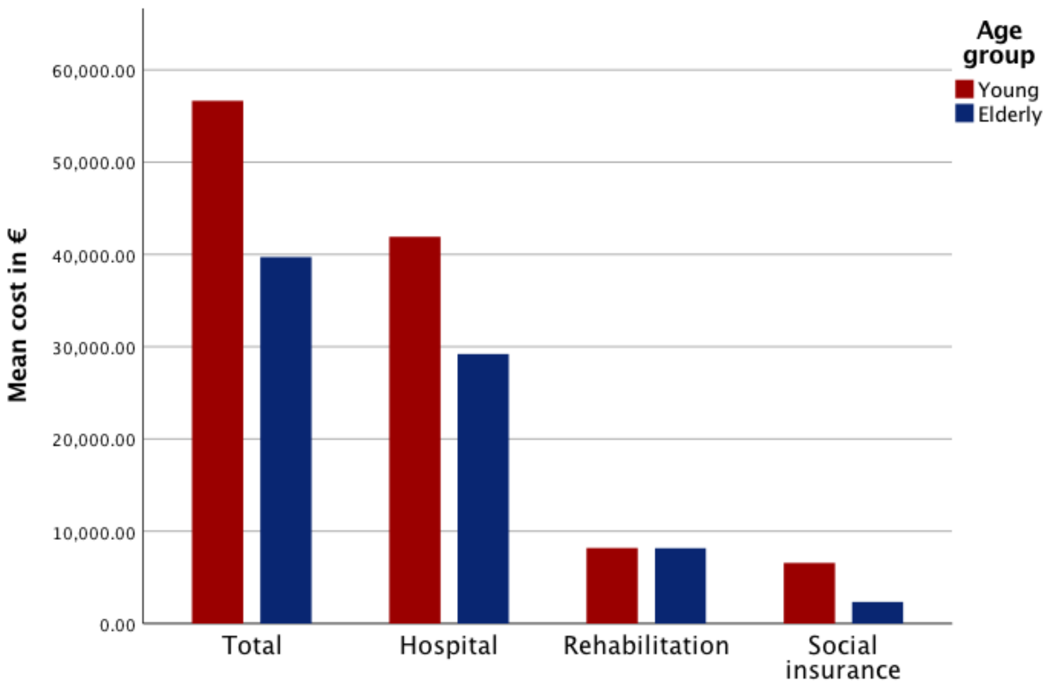
Table 3. Resource use

	Age <75 (n=1073)	Age ≥75 (n=212)	*p*
Cost of treatments in €, median (IQR)			
Hospital costs	29 971 (13 381-50 212)	18 356 (9 740-37 102)	<0.001

Rehabilitation	0 (0-6 543)	0 (0-7 574)	0.928
Social Insurance Institution	1 669 (579-6 686)	714 (392-1 760)	<0.001
Cost of treatment of those with CPC 1-2 after 12 months in €, median (IQR) (57%)			
Hospital	41 194 (27 031-63 709)	34 888 (19 083-60 029)	0.071
Rehabilitation	2113 (0-9 603)	6073 (417-13 319)	0.012
Social Insurance Institution	4 561 (1 173-15 043)	2 049 (1 196-3 509)	<0.001
Total cost in €, median (IQR)			
Everyone	38 195 (16 505-71680)	22 641 (12 488-47 006)	<0.001
Those with CPC 1-2 after 12 months (57)	54 510 (36 148-86 461)	39 482 (24 101-93 020)	0.040
Effective cost[1] in €			
Of those with CPC 1-2 after 12 months	119 941	168 416	-
Effective cost in € among those with CPC 1-2 after 12 months			
OHCA	90 499	133 134	-
IHCA	161 670	199 540	-
ICUCA	308 000	172 595	-

[1]Effective cost: The total healthcare-associated costs of all patients within their respective age group divided by the number of survivors with a favourable neurological outcome

Figure 1. Mean cost distribution in 2021 euros



Neurological outcome and mortality

Neurological outcome was worse for the elderly group, with only 24% (50/212 patients) having CPC scores of 1–2 after 12 months, compared with 47% (507/1073 patients) of the younger age group, $p < 0.001$. Long-term mortality was higher for the elderly group compared to the younger group; 70% of the elderly (vs. 44%) had died within two years, $p < 0.001$. Mortality in the elderly versus the younger age group during the first year is shown in Figure 2. Separate Kaplan Meier curves illustrating mortality during the whole follow-up period for all patients, patients based on location of arrest (OHCA, IHCA and ICUCA) as well as based on initial rhythm (shockable and non-shockable) can be found in the supplementary material (Additional file 5-6). The median follow-up time was 1.6 years per patient.

Factors independently associated with unfavourable neurological outcome was age above 75 years (OR = 3.27, 95% CI: 2.12-5.03, $p < 0.001$), dependent pre-admission functional status (OR = 3.13, 95% CI: 1.69-5.79, $p < 0.001$), non-shockable initial CA rhythm (OR shockable rhythm = 0.43, 95% CI: 0.30-0.60, $p < 0.001$), time to ROSC in 10 minutes (OR = 1.61, 95% CI: 1.34-1.93, $p < 0.001$) and APACHE II score excluding points for age (OR = 1.96, 95% CI: 1.61–2.39, $p < 0.001$).

Factors independently associated with mortality were age above 75 years (OR = 3.36, 95% CI: 2.21-5.11, $p < 0.001$), dependent pre-admission functional status (OR = 2.96, 95% CI: 1.60-5.50, $p < 0.001$), initial CA rhythm (OR shockable rhythm= 0.56, 95% CI: 0.40-0.77, $p < 0.001$), location of CA (ICUCA OR = 2.27, 95% CI: 1.26-4.08, $p = 0.006$), time to ROSC (OR = 1.36, 95% CI: 1.16-1.60, $p < 0.001$) and APACHE II score excluding age (OR = 2.06, 95% CI: 1.70-2.50, $p < 0.001$). Table 4 details the independent predictors of an unfavourable neurological outcome and Table 5 the independent predictors of mortality.

Table 4. Univariate models and multivariate models for risk factors predicting 12-month unfavourable cerebral performance status

	Univariate model		**Multivariate model**	
Variable	OR (95% CI)	*p*	OR (95% CI)	*p*
Age				
Young (<75y)	1		1	
Elderly (>=75)	3.09 (2.19-4.36)	<0.001	3.27 (2.12-5.03)	<0.001
Pre-admission functional status				
Independent	1		1	
Dependent	4.07 (2.48-6.67)	<0.001	3.13 (1.69-5.79)	<0.001
Initial CA-rhythm				
Non-shockable	1		1	

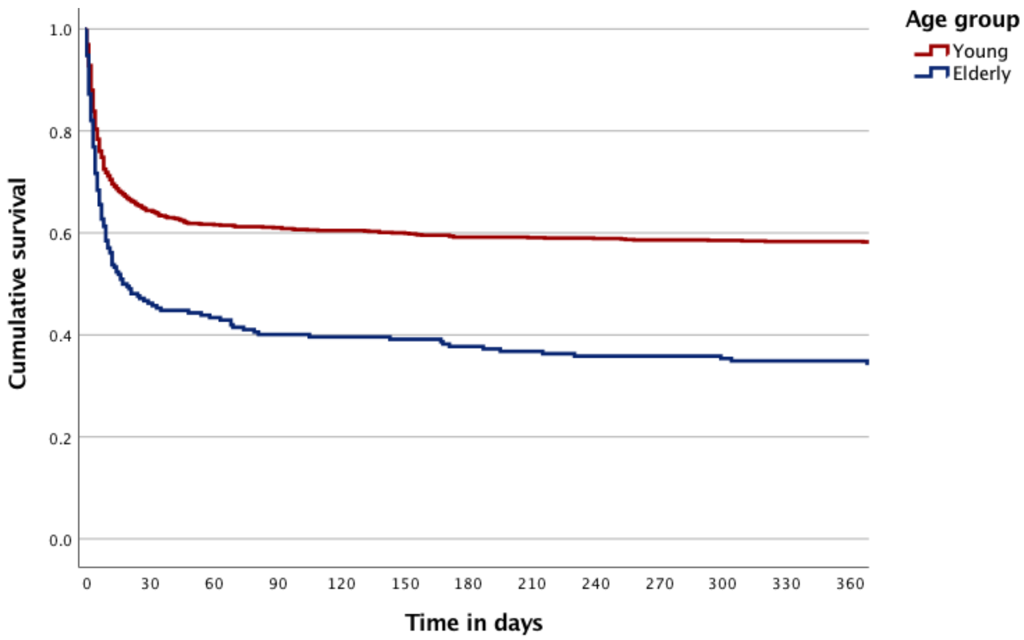
Shockable	0.32 (0.25-0.41)	<0.001	0.43 (0.30-0.60)	<0.001
Location of arrest				
OHCA	1		1	
IHCA	1.78 (1.37-2.30)	<0.001	1.46 (0.98-2.18))	0.065
ICUCA	2.24 (1.47-3.41)	<0.001	2.24(1.21-4.16)	0.010
Witnessed arrest (not witnessed=1)	0.47 (0.31-0.70)	<0.001	0.70(0.43-1.12)	0.134
Time to ROSC in 10 minutes	1.15 (1.02-1.29)	0.020	1.61 (1.34-1.93)	<0.001
APACHE II-score excluding age points[1]	2.51 (2.13-2.95)	<0.001	1.96 (1.61-2.39)	<0.001
A total of 980 patients were included. 94 patients had missing CPC, 60 patients had missing functional status, 68 patients had missing initial rhythm, 24 patients had missing if the arrest was witnessed, 118 patients had missing time to ROSC, 1 patient had missing APACHE II-score.				

[1] Each step increases the variable by 10

Table 5. Univariate models and multivariate models for risk factors predicting 12-month mortality.

	Univariate model		**Multivariate model**	
Variable	OR (95% CI)	*p*	OR (95% CI)	*p*
Age				
Young (<75y)	1		1	
Elderly (>=75)	3.44 (2.44-4.84)	<0.001	3.36 (2.21-5.11)	<0.001
Pre-admission functional status				
Independent	1		1	
Dependent	4.20 (2.55-6.92)	<0.001	2.96 (1.60-5.50)	<0.001
Initial CA-rhythm				
Non-shockable	1		1	
Shockable	0.33 (0.26-0.42)	<0.001	0.56 (0.40-0.77)	<0.001
Location of arrest				
OHCA	1		1	
IHCA	2.07 (1.61-2.67)	<0.001	1.61 (1.11-2.34)	0.12
ICUCA	2.29 (1.52-3.449	<0.001	2.27 (1.26-4.08)	0.006
Witnessed arrest (not witnessed=1)	0.59 (0.40-0.86)	<0.006	0.80 (0.51-1.27)	0.353
Time to ROSC in 10 minutes	1.04 (0.93-1.16)	0.520	1.36 (1.16-1.60)	<0.001
APACHE II-score excluding age points[1]	2.34 (2.01-2.73)	<0.001	2.06 (1.70-2.50)	<0.001
A total of 1055 patients were included. 60 patients had missing functional status, 68 patients had missing initial rhythm, 24 patients had missing if the arrest was witnessed, 118 patients had missing time to ROSC, 1 patient had missing APACHE II-score.				

Figure 2. Kaplan-Meier survival curve of all cases during the first year, Log Rank $p < 0.001$



Discussion

This current study presents a comprehensive estimation of CA-associated costs including hospital costs, rehabilitation costs and social insurance costs at a tertiary university hospital. Long-term survival and functional outcome was as expected significantly lower among the elderly. In addition they received less intensive ICU treatment and had a shorter ICU LOS overall. Cost effectiveness was lower for the elderly patient group than for the younger patient group in most cases except ICUCAs. Given our ageing population, our study highlights the need to individually assess the cost effectiveness of care post CA.

Both TISS-point distribution and the median total cost are lower for the elderly group. This in combination with an even APACHE-score distribution between the age groups (indicating roughly the same comorbidity pre-CA) indicates that age seems to have been a factor affecting treatment intensity. The difference in total TISS-point-distribution can be affected by the LOS, but the LOS does not explain the difference in average daily TISS-points. We speculate that initial treatment intensity was high for both age groups, but that some treatments were stopped earlier in the elderly group due to a perceived poor prognosis, thus decreasing the average daily TISS-score. This indicates that an active daily evaluation of patients was in use in order to allocate resources in a more beneficial way. Recent studies demonstrate that ROSC rates, one-year survival and favourable neurological outcome at one month among elderly CA patients have increased over time with increase in the

proportion of advanced in-hospital treatments (i.e. extracorporeal membrane oxygenation, therapeutic hypothermia and/or percutaneous coronary angiogram/intervention) provided [23]. In our study, in-hospital costs of the total provided treatments were lower for the elderly, even when excluding those with a poor one-year neurological outcome. One could argue that the elderly may not benefit from more aggressive treatment, but age in itself should not affect the administered treatments even if it affects mortality, as neurological outcome seems to remain good for survivors [3]. In this study, the ECPSFNO was higher for the elderly group in all locations of CA except ICUCA. Thus, although fewer resources were used by the elderly, the cost per survivor remained higher than the younger age group owing to the high mortality in the elderly group.
Due to marked differences in healthcare funding, direct comparisons of our results with other studies are difficult. Our results also indicate a clear inter-patient variation. Costs in the range of €20,000–40,000 for ICU-treated CA survivors have been determined in previous studies [24, 25]. Nonetheless, several studies and meta-analyses have shown that age negatively affects post-CA mortality [26]. Long-term survival among elderly CA patients is generally lower than that among younger age groups in the case of OHCA [27, 28].

We also looked at the distribution of costs in three separate categories (hospital costs, rehabilitation costs and social insurance costs) among different age groups. Costs were higher for the younger patient group in all categories except rehabilitation. The difference in hospital costs could be attributable to the elderly receiving less aggressive treatment and having to be in a better initial condition in order to survive CA and be taken to the ICU. Less intensive treatment is needed to attain a favourable outcome if the pre-arrest comorbidities are lower, which also decreases hospital costs. The younger age group probably received more funding from the Social Insurance Institution because they got a paid sick-leave from work. Patients over 68 years of age receive pension, which does not alter if the patient is severely ill and therefore isn't included in these calculations. The higher risk of early post-CA mortality in elderly patients might also have decreased social insurance reimbursements as compared to the younger patients. We noticed that median rehabilitation costs were higher among the elderly when only including those with a favourable 12-month neurological outcome. This could be an indicator for the elderly having more long-time problems post-CA. We can probably not see the same difference in rehabilitation costs when taking into account all patients as the early mortality among elderly decreases the median rehabilitation costs. The effect of less aggressive treatment on the need for rehabilitation among elderly is something further research could focus on.

Additionally, we demonstrated worse long-term outcome in elderly compared to younger patients following care in the ICU after CA. This difference was the most pronounced in OHCAs but was evident in patients with IHCA as well. Interestingly, this study shows that the same percentage of patients in both age groups had a CPC of 3-4 12 months post CA, but our multivariable model still indicates that age affects neurological outcome. It is debatable how much old age correlates with worse neurological outcome as the high mortality probably affects the statistics. Previous studies also indicate that there isn't a difference in neurological outcome among elderly compared to younger CA survivors[3, 28]. It is worth noting that age does not always correlate with outcome and is not in itself an adequate prognostic factor, as two elderly persons of the same age can have very different medical conditions [29]. High frailty and a low performance status have been connected with higher ECPSFNO and mortality in previous studies [30-33]. The increased mortality related to age in this study is indeed partially explained by the pre-admission functional status of the elderly patients; thus, this in combination with age seems to better predict both mortality and neurological outcome. Performance status could be a more precise tool when deciding which patients benefit the most from intensive care and more advanced treatment options.

Another possible tool for risk assessment among the elderly seems to be the initial rhythm, as an initially shockable rhythm predicts a better outcome even among the very elderly, where other prognostic factors seem to fail [34]. Supporting the results of previous studies, initial rhythm was one of the factors with the strongest association with outcome among both the younger and elderly patients in this study as well. Interestingly, in our study the elderly had lower incidences of ventricular fibrillation (VF) and ventricular tachycardia (VT) than the younger age group. This could be related to a difference in the aetiology of the arrests or to mechanisms such as faster conversion of VF/VT to asystole owing to the faster depletion of energy in the aged heart. Such an abnormality has been described in mitochondrial metabolism with ageing in the muscle cells [35]. Previous studies have also shown that bradyarrhythmia-related CA patients were generally older than those with tachyarrhythmia-related CA [36]. The significant difference in location of arrest is also something that affects mortality and neurological outcome as CA aetiology differs depending on where the CA occurred [37]. We may speculate that as the elderly had a higher percentage of IHCAs, they also had a higher amount of unfavourable pre-arrest comorbidities, which increases mortality as these comorbidities affect CA-aetiology and initial rhythm in an unfavourable manner [38]. Factors in IHCA that may decrease mortality compared to OHCAs are shorter times to response and more available treatments, but these do probably not affect mortality as much as the pre-arrest comorbidities seem to do.

A major strength of this study is its minimal selection bias owing to socioeconomic factors and personal insurance, as this study was conducted in a setting of government-funded healthcare. A limitation and factor affecting the outcome of this study is that the studied population only included patients with ROSC who were treated in the ICU; this immediately excludes patients in such a bad initial state that they did not survive until admission to the ICU and patients with low chances of benefiting from intensive treatment. This leads to a selection bias especially among the elderly, with those surviving to the ICU having a higher probability of surviving altogether and being in a better initial condition compared to the mean population with the same age.

Conclusion

The interpretation of this study is that treatment intensity for the elderly is lower as a group, the mortality, the risk for a poor neurological outcome is higher and the cost-effectiveness is lower compared to the younger age group. Further studies should focus on the tools for identification of patients who can benefit from a more aggressive treatment approach, enabling an improvement in the resource distribution in post-CA ICU care in the elderly.

Abbreviations

CA: Cardiac arrest; ICU: intensive care unit; TISS: Therapeutic scoring system; CPC: cerebral performance category; CPR: cardiopulmonary resuscitation; FICC: Finnish Intensive Care Consortium; EHR: electronic health records; ROSC: return of spontaneous circulation; WHO/ECOG: World Health Organization/Eastern Cooperative Oncology Group, APACHE: Acute Physiology and Chronic Health Evaluation; LOS: length of stay; ECPSFNO: Effective cost per survivor with favourable neurological outcome; OHCA: out-of-hospital cardiac arrest; IHCA: in-hospital cardiac arrest; ICUCA: in-intensive-care-unit cardiac arrest

Supplementary Information

Additional file 1. Table of TISS-point distribution for individual procedures
Additional file 2. Table of TISS-point distribution for individual procedures (OHCA-cases only)
Additional file 3. Table of TISS-point distribution for individual procedures (IHCA-cases only)
Additional file 4. Mean cost in euro based on initial rhythm a) shockable rhythms b) non-shockable rhythms

Additional file 5. KM-curves based on location of arrest a) all cases during the whole follow up-period, Log Rank p <0.001 b) OHCA, Log Rank $p < 0.001$ c) IHCA, Log Rank $p = 0.003$ d) ICUCA, Log Rank $p = 0.079$

Additional file 6. KM-curves based on initial rhythm a) Shockable rhythm (VF/VT), Log rank $p < 0.001$ b) Non-shockable rhythm, Log Rank $p = 0.062$

Acknowledgements

The authors wish to thank doctor Daniel Folger, who helped with the data collection.

Authors contribution

EH and MBS planned and conceived the study and wrote the first draft. RR assisted with the statistical analysis. All other authors revised the manuscript for intellectual content. All authors approve the submission. EH and MBS take intellectual responsibility for the study findings.

Funding

The study was supported by non-restricted research funding by Finska Läkaresällskapet Foundation and Medicinska Understödsföreningen Liv och Hälsa. The study sponsors had no involvement in the study design, in the collection, analysis and interpretation of data, in the writing of the manuscript or in the decision to submit the manuscript for publication.

Availability of data and materials

Legal restrictions prevent us from making the data publicly available, as it is based on patient registers. The data included in this study are obtained from several databases (The Finnish Intensive Care Consortium, Kela, the Finnish National Institute for Health and Welfare, Statistics of Finland and the five university hospitals in Finland). With appropriate research approval, data can be directly requested from the sources.

Declarations

Ethics approval and consent to participate

The study was approved by the Finnish National Institute for Health and Welfare (December 2017: THL/2034/5.05.00/2017) and the board of the Hospital District of Helsinki and Uusimaa (March 2018: HUS/26/2018).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Authors details

[1]Department of Emergency Care and Services, University of Helsinki and Helsinki University Hospital, Helsinki, Finland. [2]Department of Anaesthesiology, Intensive Care and Pain Medicine, University of Helsinki and Helsinki University Hospital, Helsinki, Finland. [3]Department of Neurosurgery, University of Helsinki and Helsinki University Hospital, Helsinki, Finland.

References

1. Porzer, M., et al., *Out-of-hospital cardiac arrest*. Biomedical papers, 2017. **161**(4): p. 348-353.
2. Zima, E., *Sudden Cardiac Death and Post Cardiac Arrest Syndrome. An Overview*. J Crit Care Med (Targu Mures), 2015. **1**(4): p. 167-70.
3. Hirlekar, G., et al., *Survival and neurological outcome in the elderly after in-hospital cardiac arrest*. Resuscitation, 2017. **118**: p. 101-106.
4. Bielecki, J.M., et al., *Disparities in a provision of in-hospital post-arrest interventions for out-of-hospital cardiac arrest (OHCA) in the elderly population-protocol for a systematic review*. Syst Rev, 2016. **5**: p. 55.
5. Segal, N., et al., *Evolution of Survival in Cardiac Arrest with Age in Elderly Patients: Is Resuscitation a Dead End?* The Journal of Emergency Medicine, 2018. **54**(3): p. 295-301.
6. Andrew, E., et al., *Long-term functional recovery and health-related quality of life of elderly out-of-hospital cardiac arrest survivors*. Resuscitation, 2018. **126**: p. 118-124.
7. Grimaldi, D., et al., *Short- and long-term outcome in elderly patients after out-of-hospital cardiac arrest: a cohort study*. Crit Care Med, 2014. **42**(11): p. 2350-7.
8. Wiel, E., et al., *Age discrimination in out-of-hospital cardiac arrest care: a case-control study*. Eur J Cardiovasc Nurs, 2018. **17**(6): p. 505-512.
9. Dumas, F., W. Bougouin, and A. Cariou, *Cardiac arrest: prediction models in the early phase of hospitalization*. Curr Opin Crit Care, 2019. **25**(3): p. 204-210.
10. Orsini, J., et al., *Prognostic factors associated with adverse outcome among critically ill elderly patients admitted to the intensive care unit*. Geriatr Gerontol Int, 2015. **15**(7): p. 889-94.
11. Reinikainen, M., et al., *Association of automated data collection and data completeness with outcomes of intensive care. A new customised model for outcome prediction*. Acta Anaesthesiol Scand, 2012. **56**(9): p. 1114-22.
12. Unertl, K. and B.M. Kottler, *[Prognostic scores in intensive care]*. Anaesthesist, 1997. **46**(6): p. 471-80.
13. Knaus, W.A., et al., *APACHE II: a severity of disease classification system*. Crit Care Med, 1985. **13**(10): p. 818-29.
14. Niewinski, G., M. Starczewska, and A. Kanski, *Prognostic scoring systems for mortality in intensive care units--the APACHE model*. Anaesthesiol Intensive Ther, 2014. **46**(1): p. 46-9.
15. Keene, A.R. and D.J. Cullen, *Therapeutic Intervention Scoring System: update 1983*. Crit Care Med, 1983. **11**(1): p. 1-3.
16. Jennett, B. and M. Bond, *Assessment of outcome after severe brain damage*. Lancet, 1975. **1**(7905): p. 480-4.
17. Perkins, G.D., et al., *Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest: a statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian and New Zealand Council on Resuscitation, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa, Resuscitation Council of Asia); and the American Heart Association Emergency Cardiovascular Care Committee and the Council on*

Cardiopulmonary, Critical Care, Perioperative and Resuscitation. Circulation, 2015. **132**(13): p. 1286-300.
18. Dyson, K., et al., *International variation in survival after out-of-hospital cardiac arrest: A validation study of the Utstein template*. Resuscitation, 2019. **138**: p. 168-181.
19. Nolan, J.P., et al., *Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update of the Utstein Resuscitation Registry Template for In-Hospital Cardiac Arrest: A Consensus Report From a Task Force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian and New Zealand Council on Resuscitation, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa, Resuscitation Council of Asia)*. Circulation, 2019. **140**(18): p. e746-e757.
20. West, H. and J.O. Jin, *Performance Status in Patients With Cancer*. JAMA Oncology, 2015. **1**(7): p. 998-998.
21. Satu Kapiainen, A.V., Taru Haula, *Terveyden- ja sosiaalihuollon yksikkökustannukset Suomessa vuonna 2011*. 2014. p. http://www.julkari.fi/handle/10024/114683.
22. Raj, R., et al., *Temporal Trends in Healthcare Costs and Outcome Following ICU Admission After Traumatic Brain Injury*. Crit Care Med, 2018. **46**(4): p. e302-e309.
23. Tagami, T., *Changes in treatments and outcomes among elderly patients with out-of-hospital cardiac arrest between 2002 and 2012: A post hoc analysis of the SOS-KANTO 2002 and 2012*. Resuscitation, 2015. **97**: p. 76-82.
24. Petrie, J., et al., *Hospital costs of out-of-hospital cardiac arrest patients treated in intensive care; a single centre evaluation using the national tariff-based system*. BMJ Open, 2015. **5**(4): p. e005797.
25. Geri, G., et al., *Healthcare costs and resource utilization associated with treatment of out-of-hospital cardiac arrest*. Resuscitation, 2020. **153**: p. 234-242.
26. Yan, S., et al., *The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis*. Crit Care, 2020. **24**(1): p. 61.
27. Chan, P.S., et al., *Long-Term Outcomes Among Elderly Survivors of Out-of-Hospital Cardiac Arrest*. J Am Heart Assoc, 2016. **5**(3): p. e002924.
28. Hiemstra, B., et al., *Long-term outcome of elderly out-of-hospital cardiac arrest survivors as compared with their younger counterparts and the general population*. Ther Adv Cardiovasc Dis, 2018. **12**(12): p. 341-349.
29. van de Glind, E.M., et al., *Pre-arrest predictors of survival after resuscitation from out-of-hospital cardiac arrest in the elderly a systematic review*. BMC Geriatr, 2013. **13**: p. 68.
30. Fernando, S.M., et al., *Frailty and associated outcomes and resource utilization following in-hospital cardiac arrest*. Resuscitation, 2020. **146**: p. 138-144.
31. Smith, R.J., D.A. Reid, and J.D. Santamaria, *Frailty is associated with reduced prospect of discharge home after in-hospital cardiac arrest*. Intern Med J, 2019. **49**(8): p. 978-985.
32. Xu, P., et al., *Clinical Frailty Scale is more likely to be related to hospital mortality for frail patients suffering in-hospital cardiac arrest*. Resuscitation, 2020. **148**: p. 215-217.
33. Wharton, C., E. King, and A. MacDuff, *Frailty is associated with adverse outcome from in-hospital cardiopulmonary resuscitation*. Resuscitation, 2019. **143**: p. 208-211.
34. Sulzgruber, P., et al., *Age-specific prognostication after out-of-hospital cardiac arrest – The ethical dilemma between 'life-sustaining treatment' and 'the right to die' in the elderly*. European Heart Journal: Acute Cardiovascular Care, 2016. **6**(2): p. 112-120.
35. Kujoth, G.C., et al., *Mitochondrial DNA mutations, oxidative stress, and apoptosis in mammalian aging*. Science, 2005. **309**(5733): p. 481-4.
36. Watanabe, E., et al., *Sudden cardiac arrest recorded during Holter monitoring: prevalence, antecedent electrical events, and outcomes*. Heart Rhythm, 2014. **11**(8): p. 1418-25.
37. Witten, L., et al., *Reasons for death in patients successfully resuscitated from out-of-hospital and in-hospital cardiac arrest*. Resuscitation, 2019. **136**: p. 93-99.
38. Andersen, L.W., et al., *In-Hospital Cardiac Arrest: A Review*. Jama, 2019. **321**(12): p. 1200-1210.

Tables and figures

Table 1. Patients characteristics

Table 2. Intensive care unit-factors

Table 3. Resource use

Table 4. Univariate models and multivariate models for risk factors predicting 12-month unfavourable cerebral performance status

Table 5. Univariate models and multivariate models for risk factors predicting 12-month mortality

Figure 1. Mean cost distribution in 2021 euros

Figure 2. Kaplan-Meier survival curve of all cases during the first year, Log Rank $p < 0.001$

Additional Files

Additional file 1. Table of TISS-point distribution for individual procedures

Procedure, no (%)	**Age <75 (n=1073)**	**Age ≥75 (n=212)**	***p***
Tracheostomy care	50 (5)	5 (2)	0.130
Controlled ventilation with or without PEEP combined with IMV or assisted ventilation	1055 (98)	197 (93)	<0.001
Cardiac arrest or countershock within 48 h	976 (91)	182 (86)	0.023
Controlled ventilation with intermittent or continuous muscle relaxants	530 (49)	59 (28)	<0.001
Pulmonary artery catheter	271 (25)	46 (22)	0.272
Pacemaker on standby	78 (7)	30 (14)	0.001
Hemofiltration/dialytic techniques	101 (9)	19 (9)	0.837
Induced hypothermia	450 (42)	34 (16)	<0.001
Intra-aortic balloon pressure	51 (5)	16 (8)	0.094
Emergency endoscopy or bronchoscopy	249 (23)	39 (18)	0.125
Vasoactive drug infusion (> 1 drug)	503 (47)	80 (38)	0.015
Intravenous alimentation	286 (27)	43 (20)	0.052
Frequent infusions of blood products (>5 U/24h)	54 (5)	14 (7)	0.350
Vasoactive drug infusion (1 drug)	891 (83)	172 (81)	0.502
Continuous antiarrhythmic infusions	212 (20)	35 (17)	0.273
Cardioversion for arrhythmia	94 (9)	16 (8)	0.564
Arterial line	1071 (100)	211 (100)	0.432
Measurement of cardiac output by any method	390 (36)	48 (23)	<0.001
Active diuresis for fluid overload or cerebral edema	658 (61)	143 (68)	0.092

Active Rx for metabolic acidosis	127 (12)	31 (15)	0.259
Active anticoagulation (initial 48h)	858 (80)	150 (71)	0.003
Rx of seizures	140 (13)	13 (6)	0.004
Central venous pressure	795 (74)	123 (58)	<0.001
Hemodialysis in unstable patient	18 (2)	8 (4)	0.048
Gastrointestinal feedings	337 (31)	53 (25)	0.064
ECG monitoring	1072 (100)	212 (100)	0.657
Hourly vital signs	1071 (100)	212 (100)	0.529
Chronic anticoagulation	679 (63)	114 (54)	0.009
Gastrointestinal decompression	975 (91)	170 (80)	<0.001
PEEP = Positive end-expiratory pressure, IMV = Intermittent mandatory ventilation, ECG = electrocardiogram			

Additional file 2. Table of TISS-point distribution for individual procedures (OHCA-cases only)

Procedure, no (%)	**Age <75 (n=691)**	**Age ≥75 (n=92)**	***p***
Tracheostomy care	20 (3)	0 (0)	0.098
Controlled ventilation with or without PEEP combined with IMV or assisted ventilation	688 (100)	89 (97)	0.003
Cardiac arrest or countershock within 48 h	632 (92)	75 (82)	0.002
Controlled ventilation with intermittent or continuous muscle relaxants	421 (61)	34 (37)	<0.001
Pulmonary artery catheter	5 (1)	0 (0)	0.413
Pacemaker on standby	21 (3)	7 (8)	0.027
Hemofiltration/dialytic techniques	23 (3)	0 (0)	0.076
Induced hypothermia	429 (62)	32 (35)	<0.001
Intra-aortic balloon pressure	13 (2)	2 (2)	0.847
Emergency endoscopy or bronchoscopy	133 (19)	13 (14)	0.236
Vasoactive drug infusion (> 1 drug)	316 (46)	38 (41)	0.423
Intravenous alimentation	166 (24)	14 (15)	0.059
Frequent infusions of blood products (>5 U/24h)	15 (2)	1 (1)	0.490
Vasoactive drug infusion (1 drug)	579 (84)	77 (84)	0.981
Continuous antiarrhythmic infusions	100 (15)	11 (12)	0.516
Cardioversion for arrhythmia	43 (6)	5 (5)	0.767
Arterial line	690 (100)	91 (99)	0.093
Measurement of cardiac output by any method	249 (36)	19 (21)	0.003

Active diuresis for fluid overload or cerebral edema	418 (61)	68 (74)	0.013
Active Rx for metabolic acidosis	48 (7)	7 (8)	0.815
Active anticoagulation (initial 48h)	599 (87)	70 (76)	0.007
Rx of seizures	96 (14)	10 (11)	0.426
Central venous pressure	528 (76)	52 (57)	<0.001
Hemodialysis in unstable patient	1 (0)	0 (0)	0.715
Gastrointestinal feedings	204 (30)	26 (28)	0.803
ECG monitoring	691 (100)	92 (100)	-
Hourly vital signs	691 (100)	92 (100)	-
Chronic anticoagulation	453 (66)	50 (54)	0.035
Gastrointestinal decompression	657 (95)	85 (92)	0.277

PEEP = Positive end-expiratory pressure, IMV = Intermittent mandatory ventilation, ECG = electrocardiogram

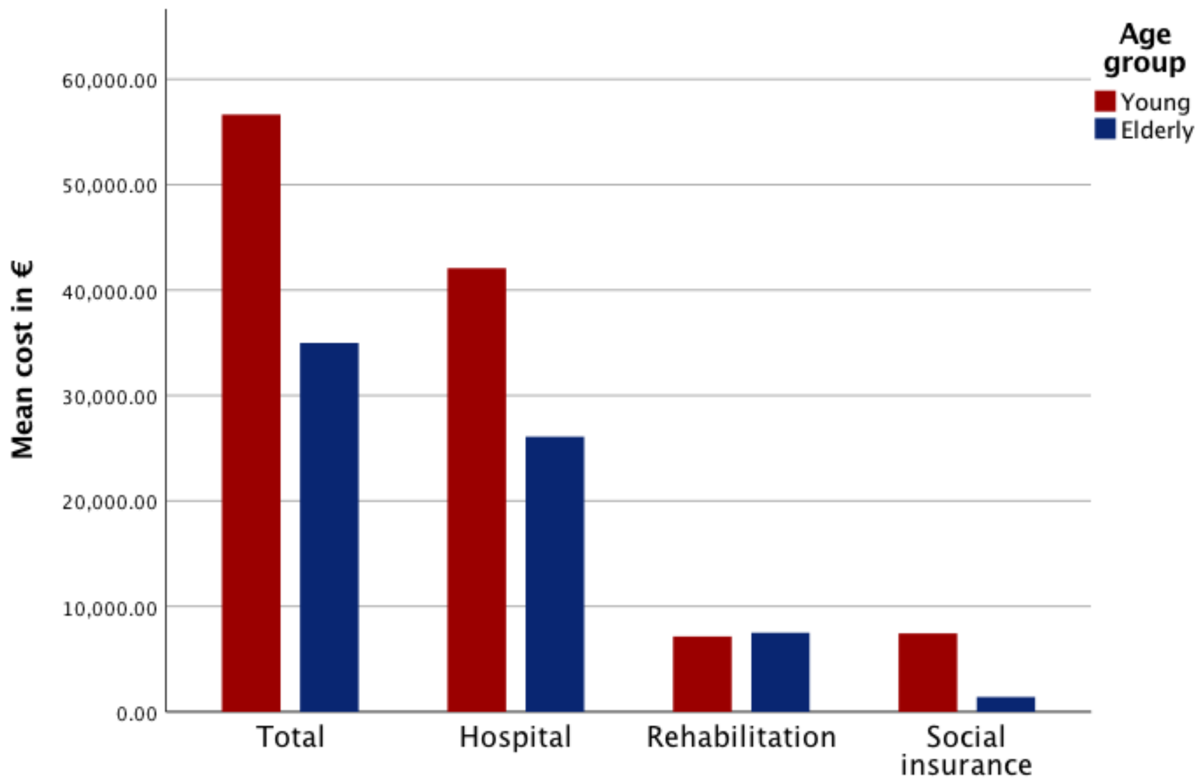
Additional file 3. Table of TISS-point distribution for individual procedures (IHCA-cases only)

Procedure, no (%)	**Age <75 (n=382)**	**Age ≥75 (n=120)**	***p***
Tracheostomy care	30 (8)	5 (4)	0.167
Controlled ventilation with or without PEEP combined with IMV or assisted ventilation	367 (96)	108 (90)	0.010
Cardiac arrest or countershock within 48 h	344 (90)	107 (90)	0.779
Controlled ventilation with intermittent or continuous muscle relaxants	109 (29)	25 (21)	0.096
Pulmonary artery catheter	5 (1)	0 (0)	0.208
Pacemaker on standby	57 (15)	23 (19)	0.268
Hemofiltration/dialytic techniques	78 (20)	84 (16)	0.267
Induced hypothermia	21 (6)	2 (2)	0.080
Intra-aortic balloon pressure	38 (10)	14 (12)	0.590
Emergency endoscopy or bronchoscopy	116 (30)	26 (22)	0.065
Vasoactive drug infusion (> 1 drug)	187 (49)	42 (35)	0.007
Intravenous alimentation	120 (31)	29 (24)	0.130
Frequent infusions of blood products (>5 U/24h)	39 (10)	13 (11)	0.845
Vasoactive drug infusion (1 drug)	312 (82)	95 (80)	0.541
Continuous antiarrhythmic infusions	112 (29)	24 (20)	0.045
Cardioversion for arrhythmia	51 (13)	11 (9)	0.224
Arterial line	381 (100)	120 (100)	0.575

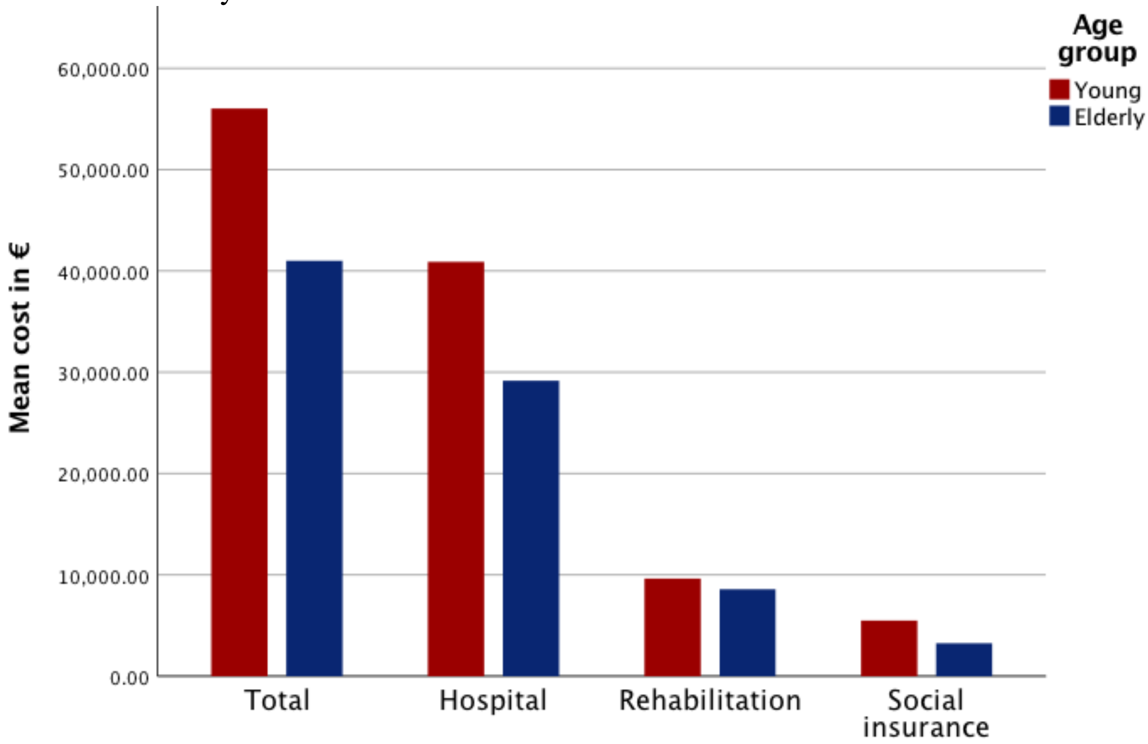
Measurement of cardiac output by any method	141 (37)	29 (24)	0.010
Active diuresis for fluid overload or cerebral edema	240 (63)	75 (63)	0.948
Active Rx for metabolic acidosis	79 (21)	24 (20)	0.872
Active anticoagulation (initial 48h)	259 (68)	80 (67)	0.817
Rx of seizures	44 (12)	3 (3)	0.003
Central venous pressure	267 (70)	71 (59)	0.029
Hemodialysis in unstable patient	17 (5)	8 (7)	0.330
Gastrointestinal feedings	133 (35)	93 (23)	0.012
ECG monitoring	381 (100)	120 (100)	0.575
Hourly vital signs	380 (100)	120 (100)	0.427
Chronic anticoagulation	226 (59)	64 (53)	0.259
Gastrointestinal decompression	318 (83)	85 (71)	0.003
PEEP = Positive end-expiratory pressure, IMV = Intermittent mandatory ventilation, ECG = electrocardiogram			

Additional file 4. Mean cost in euro based on initial rhythm

a) shockable rhythms

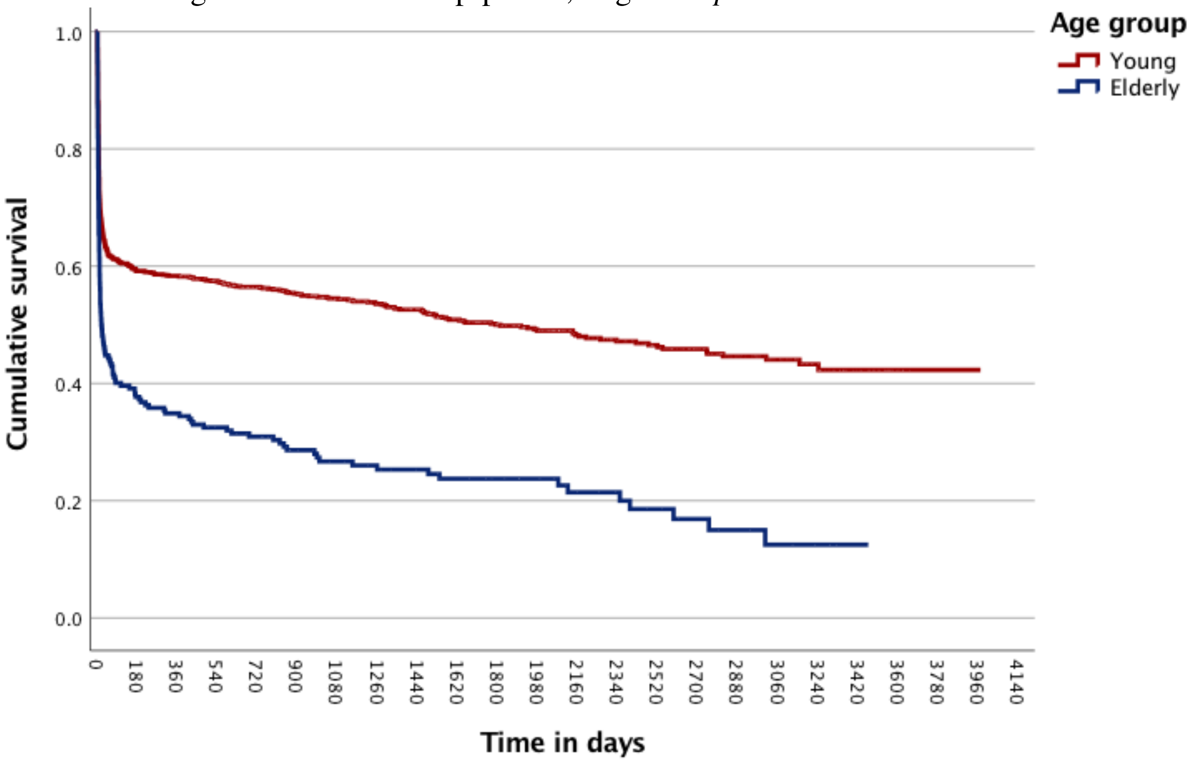


b) non-shockable rhythms

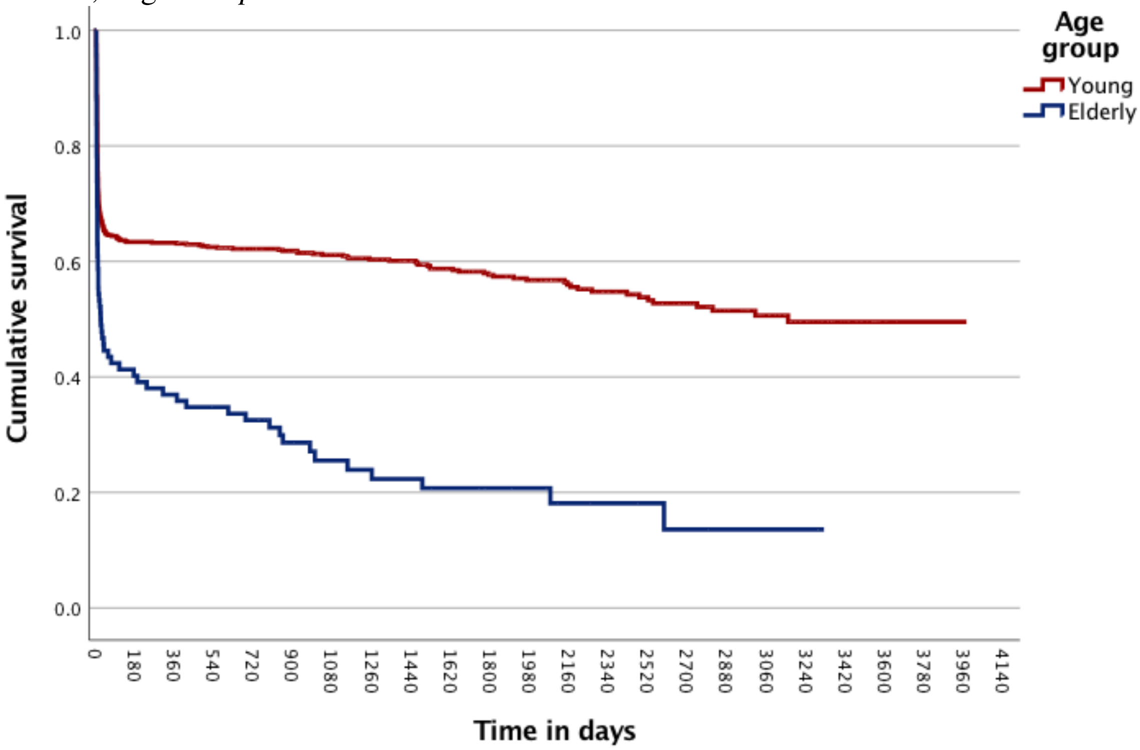


Additional file 5. KM-curves based on location of arrest

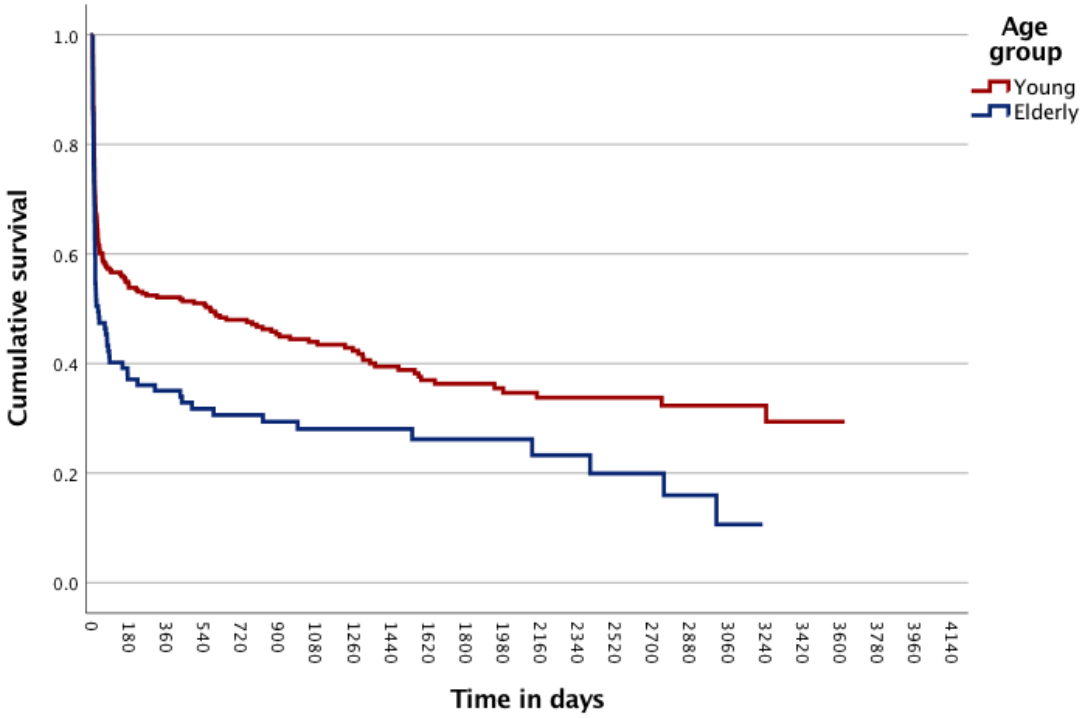
a) All cases during the whole follow up-period, Log Rank $p < 0.001$



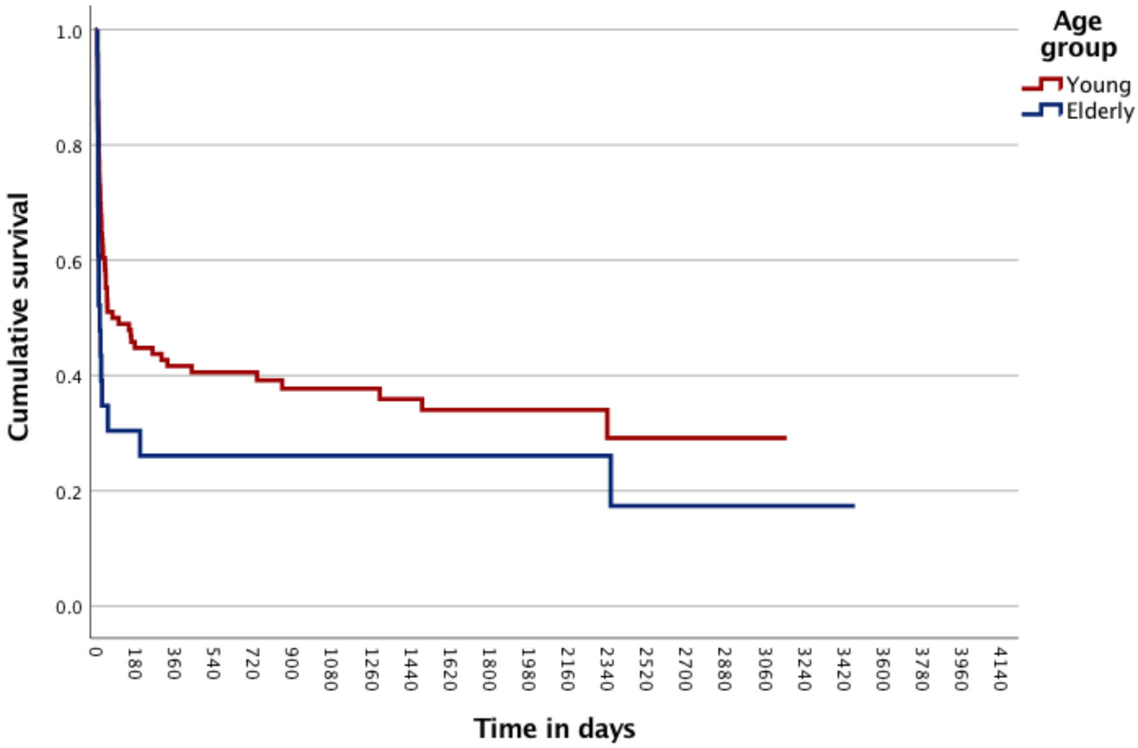
b) OHCA, Log Rank $p < 0.001$



c) IHCA, Log Rank $p = 0.003$

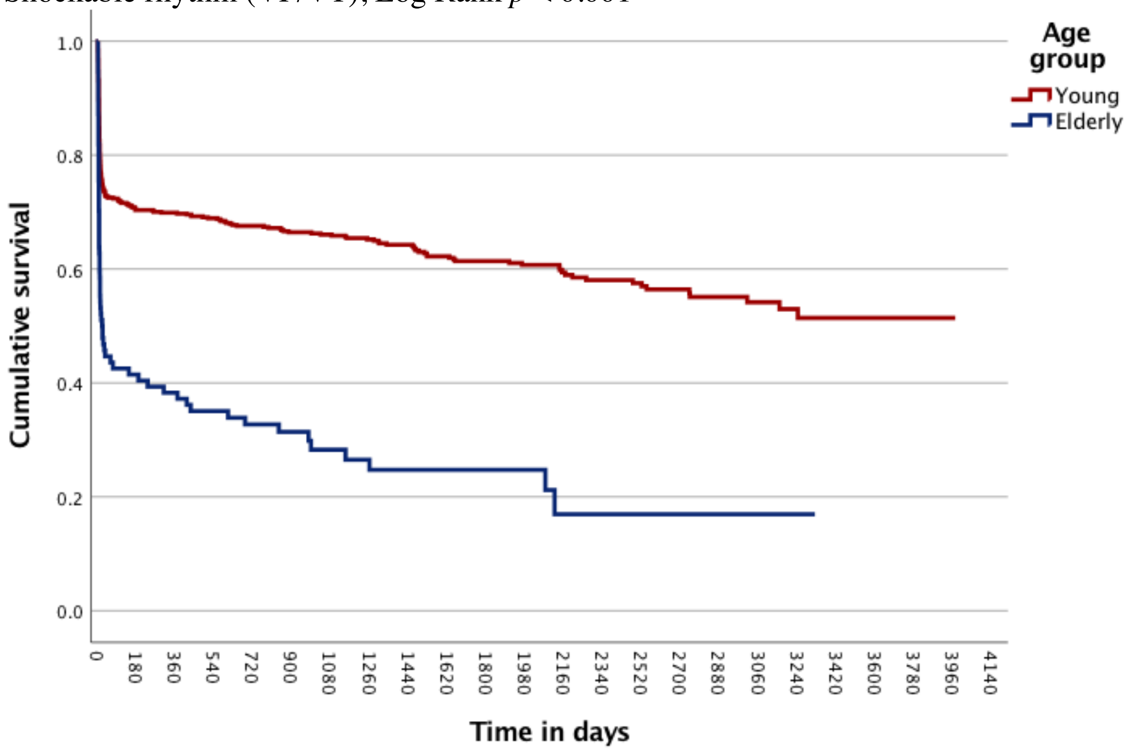


d) ICUCA, Log Rank $p = 0.079$

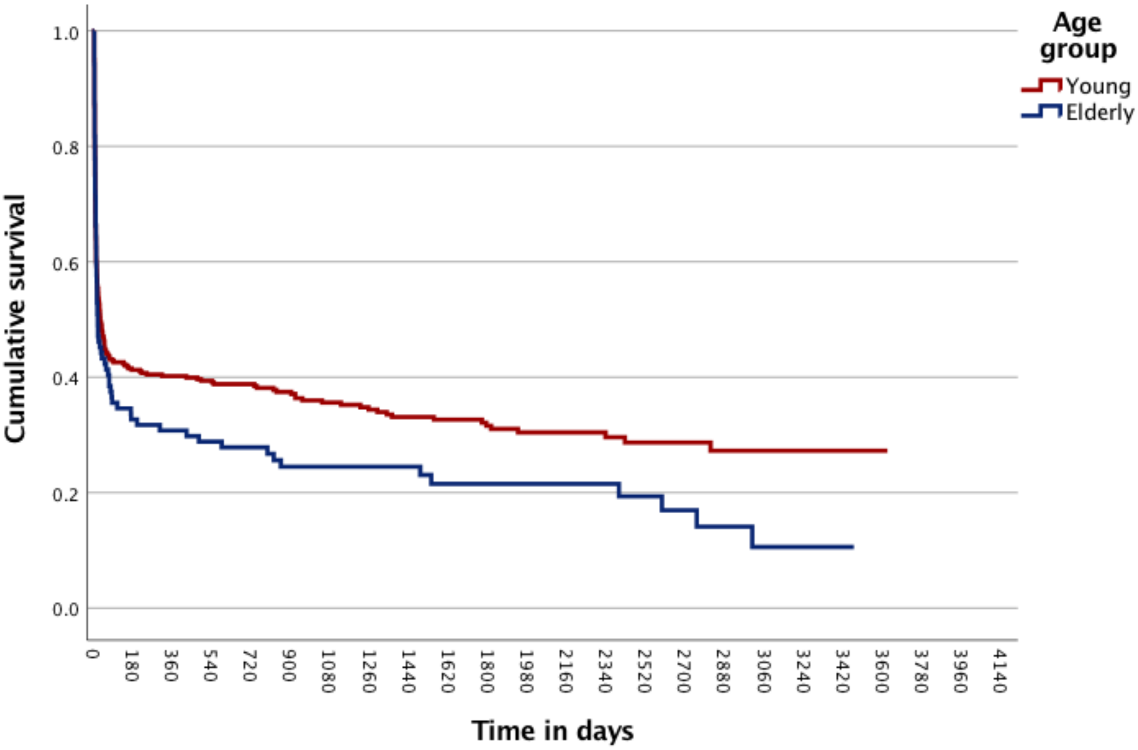


Additional file 6. KM-curves based on initial rhythm

a) Shockable rhythm (VF/VT), Log Rank $p < 0.001$



b) Non-shockable rhythm, Log Rank $p = 0.062$



Age group
Young
Elderly
Cumulative survival
1.0
0.8
0.6
0.4
0.2
0.0
0
180
360
540
720
900
1080
1260
1440
1620
1800
1980
2160
2340
2520
2700
2880
3060
3240
3420
3600
3780
3960
4140
Time in days

460