“Impact of age on management and prognosis of resuscitated sudden cardiac death patients”

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Abstract

Background: Sudden cardiac death (SCD) has a great impact on healthcare due to cardiologic and neurological complications. Admissions of elderly people in Cardiology Intensive Care Units have increased. We assessed the impact of age in presentation, therapeutic management and in vital and neurological prognosis of SCD patients.

Methods: We carried out a retrospective, observational, multicenter registry of patients who were admitted with a SCD in 5 tertiary hospitals from January 2013 to December 2020. We divided our cohort into two groups (patients < 80 years and ≥ 80 years). Clinical, analytical and hemodynamic variables as well as in-hospital management were registered and compared between groups. The degree of neurological dysfunction, vital status at discharge and the influence of age on them were also reviewed.

Results: We reviewed 1160 patients admitted with a SCD. 11.3% were ≥ 80 years. Use of new antiplatelet agents, performance of a coronary angiography, use of pulmonary artery catheter and temperature control were less carried out in the elderly. Age, non-shockable rhythm, Killip class > 1 at admission, time to CPR initiation > 5 min, time to ROSC > 20 min and lactate > 2 mmol/L were independent predictors for in-hospital mortality. Non-shockable rhythm, Killip class > 1 at admission, time to CPR initiation > 5 min and time to ROSC > 20 min but not age were independent predictors for poor neurological outcomes.

Conclusions: Age determined a less aggressive management and it was associated with a worse vital prognosis in patients admitted with a SCD. Nevertheless, age was not associated with worse neurological outcomes.

1. Introduction

Sudden cardiac death (SCD) is defined as an unexpected cardiac arrest due to a heart condition, that occurs within one hour of symptoms onset. Nowadays, it represents the third leading cause of death in Europe (15–20%) and accounts for 50% of cardiovascular deaths in Western Europe.

Abbreviations: SCD, Sudden cardiac death; CPR, Cardiopulmonary resuscitation; ROSC, Recovery of spontaneous circulation; CA, Cardiac arrest; ADL, Activities of daily living; EI-MV, Endotracheal intubation with mechanical ventilation; CAG, Coronary angiography; TC, Temperature control; NSE, Neuronal specific enolase; CPC, Cerebral performance category; CCI, Charlson Comorbidity Index.

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Pre-hospital care protocols for SCD patients and the spread of cardiopulmonary resuscitation (CPR) / automated external defibrillator (AED) training courses together with the progressive aging of the population have increased the number of elderly patients admitted to Cardiology Intensive Care Units (CICU) with an aborted SCD [3–5]. Impact of SCD patients on health care systems is high due to cardiologic and mainly neurologic complications that could lead to poor vital and functional prognosis of these patients [6]. This is especially relevant in the elderly since morbidity and disability clearly increase with age, further worsening their vital and neurologic prognosis.

Even though the development of standardized protocols have improved the prognosis of patients hospitalized after SCD [7,8], their mortality and morbidity, especially in the older population, remain unacceptably high. Moreover, elderly patients are usually underrepresented in clinical trials, so the evidence for some techniques or procedures in the setting is limited. For instance, they may not receive some of the medical therapies that have been reported to improve the prognosis based on the assumption of a per se poor prognosis [9,10]. Although cardiac arrest guidelines, ethical statements, and clinical procedures do not propose age as a criterion for discrimination in SCD care [11], physicians are often faced with having to decide whether certain diagnostic tests or therapies may be beneficial or futile in older patients [12].

The aim of this observational study is to assess whether the age could have an influence in the etiology, clinical presentation and therapeutic management of patients admitted with a SCD in tertiary hospitals. Furthermore, we aimed to evaluate whether these possible differences could affect vital and neurological outcomes of these patients.

2. Methods

2.1. Study population

In this retrospective study, we reviewed all consecutive patients admitted from January 2013 to December 2020 with an aborted SCD to CICUs of 5 third-level hospitals in Catalonia, Spain (Hospital Universitari Dr. Josep Trueta, Hospital Universitario de Bellvitge, Hospital Universitario Joan XXIII, Hospital Universitario Germans Trias i Pujol and Hospital de la Santa Creu i Sant Pau). Inclusion criteria were: a) ≥ 18 years of age and b) diagnosis of SCD according to current guidelines [1,2]. Exclusion criteria were: a) patients not recovered from SCD prior to hospital admission and b) cardiac arrest (CA) due to an extracardiac condition.

The study was conducted in accordance with the standards set by the “Declaration of Helsinki” and was approved by the Clinical Research Ethics Committe. Informed consent was waived due to the retrospective nature of the study.

2.2. Study variables

Patient-related factors were collected from medical reports or by anamnesis to relatives at admission. We divided our cohort in two groups as follows: the “younger” group refers to patients < 80 years while the “older” or “elderly” group refers to patients ≥ 80 years. This cut-off age was chosen to achieve a better differentiation between the two groups. We identified those patients who were dependent for the basic activities of daily living (ADL) and we calculated the Charlson Comorbidity Index (CCI) [13]. Biochemical and hematological parameters were measured by standard procedures in first blood test and arterial blood gas samples at admission; the estimated glomerular function rate was calculated by the Modification of Diet in Renal Disease Study equation (MDRD) [14].

We considered resuscitation parameters such as location of CA, witnessed CA, initial recorded rhythm, use of AED and resuscitation times. Time to CPR initiation was defined as the time from cardiac arrest to the initiation of CPR maneuvers (by health or non-health personnel). Shockable rhythm was considered if ventricular fibrillation (VF), pulseless ventricular tachycardia (VT), or shockable rhythm according to AED were the first rhythms obtained. All these resuscitation parameters were collected from medical emergency services reports. First EKG post ROSC achieved and hemodynamic variables upon arrival at the hospital were also analyzed.

Management during hospital admission was at the discretion of the treating physician and according to availability in each hospital. Percentage of endotracheal intubation with mechanical ventilation (EI-MV), use of inotropes, intra-aortic balloon pump (IABP), pulmonary artery catheter (PAC), renal replacement therapy (RRT) as well as coronary angiography (CAG) performance and emergency/urgent percutaneous coronary intervention (PCI) were reported. In patients who underwent CAG, number of affected vessels, culprit vessel and TIMI flow grade after PCI were also recorded.

Temperature control (TC) was performed using surface or endovascular cooling devices according to availability in each hospital at a temperature of 33 °C. TC complications and reasons not to start or to stop it were examined. We also reviewed the presence of myoclonus or status epilepticus as well as the performance of an electroencephalogram (EEG), use of anticonvulsant medication or the induction of a barbiturate coma. We registered the absence of brain stem reflexes and spontaneous mobilization at 72 h after SCD. Performance of somatosensory evoked potentials N20 (SSEP-N20) and brain magnetic resonance imaging (MRI) were also recorded. We registered neuronal specific enolase (NSE) at 24 h, 48 h and 72 h if available. To categorize neurological function at discharge, the Cerebral Performance Category (CPC) scale was used [15]. For patients who died from non-neurological causes, the last known previously achieved CPC category was considered. If the patient died from a non-neurological cause before a CPC category could be established (i.e., patients who died while still under sedation with no possibility of CPC assessment) it was categorized as unknown CPC. The population was divided into 2 groups: good neurological prognosis (CPC 1-CPC 2) and poor neurological prognosis (CPC 3-CPC 5). Patients with unknown CPC were excluded from neurological prognosis analysis. Restriction of invasive procedures as well as in-hospital mortality and causes of death were also registered.

2.3. Statistical analysis

Results are presented as the mean (standard deviation) for continuous variables with a normal distribution, medians for continuous variables with a non-Gaussian distribution, and percentages for categorical variables. The characteristics of patients with age < 80 years and age ≥ 80 years were compared using the x² test or Fisher exact test for categorical variables. For quantitative variables, they were analyzed by t-test in the case of normal distribution, or Mann-Whitney U test in the case of a non-normal distribution.

Multivariate analysis to evaluate the effect of variables on the incidence of in-hospital mortality and neurologic prognosis at discharge were performed using Cox proportional hazard modelling that included terms that showed p < 0.1 in the univariate analysis, as well as those previously reported to provide prognostic information [16]. Significance level was set at p < 0.05. All statistical analyses were performed using Stata 13.0 for Windows.

3. Results

The 5 participating centers recorded 1160 patients with an aborted SCD between 2013 and 2020. One hundred and thirty-one patients (11.3%) were ≥ 80 years and 27 patients (2.3%) were dependent for the basic ADL.
3.1. Differences in baseline characteristics between groups

Differences in baseline characteristics at admission of both groups are detailed in Table 1. Patients aged ≥ 80 years were more frequently women, hypertensive, diabetic and dyslipidemic. In addition, there was also a higher percentage of patients with a history of coronary artery disease, respiratory disease, cerebrovascular disease and chronic kidney disease in older patients. As expected, patients ≥ 80 years had a higher CCI and they were in more percentage dependents for basic ADL.

Regarding the location of the CA, in elderly patients, it occurred more frequently in a healthcare center and less frequently in a public place or at home. They had a lower percentage of a first shockable rhythm and a shorter time to ROSC, but no differences were found in percentage of witnessed SCD or in time to initiation of CPR.

When ROSC was achieved, elderly patients more frequently presented a first EKG without repolarization alterations or with left bundle branch block, while in younger patients a higher proportion of ST segment elevation was documented. Recovery of sinus rhythm was also lower in the older group.

No differences were found in systolic blood pressure or LVEF upon hospital arrival. First arterial blood gases showed a better pH value in elderly patients, while no differences were recorded in lactate levels. First blood test showed that older group had a lower glomerular filtration and a lower hemoglobin and white blood cells count. No other analytical or hemodynamic differences were found between groups.

3.2. Differences in etiology and therapeutic management between groups

Differences in etiology of SCD and therapeutic management of both groups are detailed in Table 2. In the elderly group, the percentage of SCD attributed to STEMI was lower while that attributed to bradyarrhythmias and dilated ischemic cardiomyopathy was higher than in younger patients.

No differences were found in the percentage of either anterior STEMI location or in Killip class > 1. Use of inotropes and IABP did not differ between groups, but PAC was less used in elderly patients even after excluding those patients dependent for basic ADL. ECMO was started in only 1.9% of the cases (21 patients), all of them ≥ 80 years old.

An emergent CAG was performed less frequently in older patients. Although there was a lower percentage of patients with ST segment elevation in the elderly group, if we only included patients with elevated ST on the baseline EKG, differences were still significant. Differences were maintained despite excluding from the analysis patients who were dependent for basic ADL. No differences were found in the percentage of PCI performed or in the initial TIMI grade flow, but a significant lower use of new antiplatelet agents and a higher proportion of TIMI grade flow < 3 after PCI were shown in older patients.

The use of TC showed significant differences between groups. TC was used in a smaller percentage of the elderly patients and significance was maintained despite including only patients who had pulseless VT/ VF as the first rhythm. After excluding patients who were dependent for basic ADL, the differences remained significant. No differences were documented in the percentage of early withdrawal from TC in both groups.

3.3. Differences in prognostic stratification and outcomes between groups

Clinical previously established indicators of poor outcome (status myoclonus ≤ 72 h, absence of stem reflexes at ≥ 72 h and absence of spontaneous movements other than extension ≥ 72 h) did not differ between groups. Similarly, no differences were found in status epilepticus, use of anticonvulsant medication or induction of barbiturate coma percentage. A lower percentage of EEGs was performed in the group of elderly people. Moreover, a lower number of SSEP-N20 and brain MRI tests were also requested in older patients even though no differences in percentage of cerebral tomography were found between
A univariate analysis was performed to assess variables associated with in-hospital mortality. A Cox proportional hazard regression analysis was performed including the well-known outcome predictors in SCD patients and those variables found statistically significant in the univariate analysis. Age, non-shockable rhythm, time to CPR initiation > 5 min, time to ROSC > 20 min, a Killip class > 1 and lactate > 2 mmol/L at admission were independent predictors associated with in-hospital mortality in these patients. Detailed results are shown in Table 4.

3.5. Predictors of poor neurologic outcome

We performed a univariate analysis to identify prognostic variables of poor neurologic outcomes among patients in whom CPC assessment was available. Based on the variables with p value < 0.1 in the univariate analysis those with a known prognostic value in the neurological outcomes of patients with SCD, a Cox proportional hazard regression analysis was performed. A non-shockable rhythm, time to CPR initiation > 5 min, time to ROSC > 20 min and Killip class > 1 at admission were included in the multivariate analysis. 

Table 1 (continued)

| Characteristic | All cohort (n = 1160) | Patients < 80 years (n = 1029) | Patients ≥ 80 years (n = 131) | P-value |
|----------------|----------------------|---------------------------------|-------------------------------|---------|
| **ANALYTICAL & HEMODYNAMIC VARIABLES** | | | | |
| Systolic blood pressure (mmHg) | 106 | 107 (87–127) | 105 | 0.950 |
| Heart rate (bpm) | 78 (65–89) | 79 (62–85) | 72.9 | 0.008 |
| Lactate (mmol/L) | 5.2 | 5.2 (2.6–8.8) | 5.2 (2.9–8.2) | 0.618 |
| eGFR (ml/min/1.73 m²) | 60.0 | 61.5 (46.0–79.1) | 44.7 | <0.001 |
| AST (U/L) | 107 | 107 (54–206) | 96 (41–248) | 0.988 |
| Hemoglobin (g/L) | 135 | 136 | 121 | <0.001 |
| Leukocytes (x10⁹/L) | 14.4 | 14.6 | 12.5 | 0.002 |
| Platelets (x10¹²/ mm³) | 208 | 211 (171–262) | 198 (148–247) | 0.085 |
| C-reactive protein (mg/dl) | 9.5 | 8.5 (2.5–62.2) | 13.0 (4.1–69.7) | 0.215 |

Continuous variables are expressed as median (IQR) and categorical data as % (n).

ADL: Activities of daily living; CPR: Cardiopulmonary resuscitation; CA: cardiac arrest; AED: Automatic external defibrillator; EKG: Electrocardiogram; ROSC: Recovery-of-spontaneous-circulation; LVEF: Left ventricle ejection fraction; eGFR: Estimated glomerular filtration rate; IQR: interquartile range.

3.4. Predictors of in-hospital mortality

A univariate analysis was performed to assess variables associated with in-hospital mortality. A Cox proportional hazard regression analysis was performed including the well-known outcome predictors in SCD patients and those variables found statistically significant in the univariate analysis. Age, non-shockable rhythm, time to CPR initiation > 5 min, time to ROSC > 20 min, a Killip class > 1 and lactate > 2 mmol/L at admission were independent predictors associated with in-hospital mortality in these patients. Detailed results are shown in Table 4.

Table 2

| Characteristic | All cohort (n = 1160) | Patients < 80 years (n = 1029) | Patients ≥ 80 years (n = 131) | P-value |
|----------------|----------------------|---------------------------------|-------------------------------|---------|
| **ETIOLOGY** | | | | |
| Ischemic etiology, % | 68.2 | 69.1 (706/1022) | 61.5 (80/130) | 0.085 |
| STEMI, % | 43.4 | 45.2 (463/1024) | 29.2 (38/130) | 0.001 |
| - Anterior STEMI location | 50.9 | 50.5 (234/463) | 55.3 (21/38) | 0.576 |
| NSTEMI, % | 10.4 | 10.1 (103/1024) | 13.1 (17/130) | 0.286 |
| Dilated ischemic cardiomyopathy, % | 14.2 | 13.5 (138/1024) | 20.0 (26/130) | 0.034 |
| Bradyarrhythmia, % | 3.2 (37/1156) | 1.8 (18/1026) | 14.6 (19/130) | <0.001 |
| Dilated non-ischemic cardiomyopathy, % | 7.0 (81/1157) | 7.3 (75/1027) | 4.6 (6/130) | 0.256 |
| Hypertrophic cardiomyopathy, % | 1.1 (13/1156) | 1.3 (13/1026) | 0.0 (0/130) | 0.197 |
| Valvular heart disease, % | 2.4 (28/1156) | 2.2 (23/1028) | 3.9 (5/128) | 0.263 |
| Idiopathic, % | 12.6 | 12.7 (130/1021) | 11.5 (15/130) | 0.711 |
| **THERAPEUTIC MANAGEMENT** | | | | |
| Inotropes, % | 44.6 | 44.2 (448/1014) | 47.9 (59/123) | 0.430 |
| - Multivessel disease | 39.6 | 39.2 (321/828) | 39.2 (137/350) | 0.593 |
| - Left main | 27.4 (35/128) | 27.4 (35/128) | 0.001 |
| - Left anterior descending | 21.1 (12/57) | 21.1 (12/57) | 0.001 |
| - Multivessel disease | 0.002 |

(continued on next page)
independent predictors of poor neurological outcome. Age was not a predictor of poor neurological prognosis in these patients. Detailed results are listed in Table S.

General management and predictors of in-hospital mortality and poor neurologic outcomes are illustrated in Fig. 1.

4. Discussion

To the best of our knowledge this is the largest cohort addressing the impact of age on the management and prognosis of patients with an aborted SCD. Our study has shown the following main findings: 1) age was an independent predictor for in-hospital mortality in patients admitted to hospital after an aborted SCD, 2) elderly patients were less frequently offered therapies that are currently part of the standard of care in SCD patients and 3) neurological prognosis of elderly patients that suffered an aborted SCD appeared to be similar to that of younger patients.

First, advanced age seems to be an independent predictor of inhospital mortality in patients admitted with a SCD. Our results are aligned with previous studies confirming a higher in-hospital mortality in SCD patients. As described in previous studies [17–20], we found that younger patients had a higher likelihood of survival compared with elderly patients admitted after a SCD. Interestingly, the impact of age for increased mortality was lower with respect to other variables associated with poorer prognosis such as an initial non-shockable rhythm or long resuscitation times. This is supported by the results of previous studies such as Hirlekar et al [21] who reported that despite the fact that the 30-day survival of patients with SCD decreases with age, its OR was low, suggesting that age would be a weak predictor for the vital prognosis of these patients. For this reason, we looked for possible additional causes that could explain this large difference in mortality between groups such as a distinct diagnostic and therapeutic approach. The management of elderly patients admitted to hospital with a SCD was different from that of younger patients. Although the role of CAG after a SCD is still debated, the guidelines propose that an emergent CAG should be indicated in those patients with the highest risk of a coronary occlusion (ST-segment elevation on the initial EKG, hemodynamic and/
or electrical instability) [22] while in cases where there are no classical signs of STEMI in EKG, an immediate CAG strategy appears not to be superior to a delayed angiography strategy [23]. In our study, CAG was performed less frequently in the elderly patients. This could be explained by a lower percentage of ST-elevation in this group, but when we analyzed only patients with ST-elevation, the percentage of emergent CAG in the elderly was still lower than in the younger group. Early CAG has been associated with better outcomes regardless of age in patients who presented out-of-hospital SCD with a shockable rhythm [24] being also less frequently performed in the elderly group in our cohort.

Table 4

Predictors of in-hospital mortality. Univariate and multivariate analysis (n = 1160).

| Characteristic | Alive (n = 647) | Dead (n = 513) | p-value  |
|----------------|----------------|----------------|----------|
| Age (years)    | 61.3 (51.7–72.1) | 67.1 (57.7–75.5) | <0.001 |
| Male gender, % | 74.7 (48/67) | 73.7 (378/513) | 0.708 |
| Hypertension, % | 54.7 (354/647) | 62.0 (318/513) | 0.013 |
| Diabetes mellitus, % | 23.8 (154/647) | 30.3 (155/513) | 0.013 |
| Current smoker, % | 61.4 (397/647) | 67.5 (346/513) | 0.031 |

Continuous variables are expressed as median (IQR) and categorical data as % (n).

SCD: Sudden cardiac death; STEMI: ST-elevation myocardial infarction; ADL: Activities daily living; CAG: coronary angiography; PCI: percutaneous intervention; TC: temperature control.

Table 5

Predictors of poor neurological prognosis. Univariate and multivariate analysis (n = 1160).

| Characteristic | CPC 3-4 (n = 568) | CPC 5-6 (n = 356) | p-value  |
|----------------|------------------|------------------|----------|
| Age (years)    | 61.4 (51.7-72.1) | 65.1 (54.8-73.4) | 0.008 |
| Male gender, % | 74.5 (423/568) | 80.1 (285/356) | 0.051 |
| Hypertension, % | 55.5 (315/568) | 59.3 (211/356) | 0.255 |
| Diabetes mellitus, % | 24.5 (139/568) | 27.8 (99/356) | 0.259 |
| Current smoker, % | 36.3 (206/568) | 38.3 (136/356) | 0.165 |
| Previous coronary artery disease, % | 21.7 (123/568) | 22.8 (81/356) | 0.695 |
| Chronic kidney disease, % | 8.3 (47/568) | 9.8 (35/356) | 0.177 |
| Respiratory disease, % | 10.0 (57/568) | 16.0 (57/356) | 0.007 |
| Out-of-hospital SCD, % | 76.2 (433/568) | 87.9 (313/356) | <0.001 |
| Not-witnessed SCD, % | 4.9 (28/568) | 11.0 (39/356) | 0.001 |
| No-shockable rhythm, % | 12.4 (70/566) | 43.9 (156/355) | <0.001 |
| Time to CPR initiation (min) | 1 (0–5) | 3 (0–6) | <0.001 |
| Time to ROSC (min) | 17 (10–26) | 30 (20–40) | <0.001 |
| SBP < 90 mmHg, % | 18.0 (106/589) | 37.1 (163/439) | <0.001 |
| Emergent CAG, % | 72.6 (470/647) | 65.7 (329/501) | 0.011 |
| Multivessel disease, % | 32.9 (179/544) | 40.0 (134/335) | 0.033 |
| Final TIMI flow grade < 3, % | 7.6 (39/513) | 15.4 (48/318) | <0.001 |
| Killip class > 1, % | 37.5 (100/267) | 65.4 (153/244) | <0.001 |
| LVEF < 40%, % | 36.1 (225/623) | 46.3 (211/456) | 0.001 |
| Lactate (mmol/L) | 3.5 (1.9–6.1) | 7.2 (4.6–11.4) | <0.001 |
| eGFR (ml/min/1.73 m²) | 67.2 (51.7–82.7) | 52.9 (37.8–67.9) | <0.001 |
| Hemoglobin (g/L) | 137 (122–150) | 132 (114–147) | 0.005 |
| Leukocytes (10⁹/L) | 14.1 (10.5–18.0) | 15.1 (11.5–17.7) | 0.003 |

Continuous variables are expressed as median (IQR) and categorical data as % (n).

SCD: Sudden cardiac death; CPR: Cardiopulmonary resuscitation; ROSC: Recovery of spontaneous circulation; CAG: Coronary angiography; LVEF: Left ventricle ejection fraction; eGFR: Estimated glomerular filtration rate; IQE: interquartile range.
However, our study probably lacked the power to demonstrate that it was an independent predictor for good vital prognosis.

Interestingly, among patients undergoing CAG, the rate of PCI was similar between groups, but even though they presented similar hemodynamic profile at admission, the percentage of final TIMI flow grade < 3 was higher in elderly patients. TIMI flow grade < 3 after PCI has been related to poor outcomes in patients with acute coronary syndromes [25]. In addition, as described in previous reports [26] age-related comorbidity and a higher bleeding risk could condition a lower use of new antiplatelet agents in the elderly group. This fact along with that age by itself can lead to an impaired coronary microcirculation state [27], could explain this higher rate of TIMI flow grade < 3 after PCI, and in turn, could also influence the outcomes.

We also observed that the use of PAC in our cohort was also lower in elderly patients. Although Sionis et al [28], found that the use of PAC was not associated with mortality in patients with cardiogenic shock, patients admitted with SCD may present hemodynamic instability not only secondary to myocardial dysfunction but also due to the effects of post-CA syndrome (ischemia–reperfusion damage) and the deleterious effects of TC (arrhythmic alterations, volume depletion due to polyuria). A better knowledge of the hemodynamic status of these patients may lead to a more adjusted and targeted management of their hemodynamics and may also influence their prognosis [29].

Although our results did not allow us to establish a causal relationship between the lower rate of CAG, the worse results of PCI and the worse hemodynamic monitoring with the higher cardiovascular mortality in the elderly group, given that there is evidence that these variables are associated with the outcomes of patients with SCD, we believe that they may have, at least partially, influenced it. Second, the influence of age on the neurological outcomes of SCD patients is still unclear. In management and treatment of these patients, we found a high spectrum of SCD patients admitted at CICU. Despite the improvements in management and treatment of SCD patients, we found a high spectrum of SCD patients admitted at CICU. Despite the improvements in management and treatment of SCD patients, we found a high spectrum of SCD patients admitted at CICU. Despite the improvements in management and treatment of these patients. Elderly patients received less invasive treatment even though they did not present a worse clinical profile upon arrival at the hospital, which could determine, at least in part, their worse prognosis.

According to our study, after excluding patients with an unknown CPC, neurological prognosis appeared to be similar between groups, and age was not an independent predictor for neurological outcomes. Only a non-shockable rhythm, a worse hemodynamic status and longer CPR times were associated with poor neurological prognosis in our cohort.

TC is considered an effective therapy to improve neurological outcomes in patients with a SCD [35]. A recent update in the current guidelines on temperature control after cardiac arrest in adults [36] recommend actively preventing fever instead of temperature control at 32–36 °C in these patients. In our study, we found that in the elderly patients TC at 33 °C was less performed than in the younger group. Older patients presented a lower percentage of shockable rhythms which could explain the lower use of TC in this group. However, when we analyzed the use of TC only in patients with a shockable rhythm, its use in the elderly was almost half that of younger patients. Even though in the multivariate analysis, TC was not an independent predictor for neurological prognosis, it would have been interesting to know the neurological outcome of patients who died before CPC could be assessed since results could have been different [37].

Finally, the less invasive management in elderly patients admitted for SCD in our cohort could also influence their neurological prognosis, since there are studies that show an increase in survival with a favorable neurological outcome in elderly patients admitted with SCD due to a higher proportion of aggressive treatment [38].

As a piece of real-world sample, our cohort represents the whole spectrum of SCD patients admitted at CICU. Despite the improvements in management and treatment of SCD patients, we found a high morbidity and mortality in these patients. Current therapies such as extracorporeal cardiopulmonary resuscitation (ECPR) represent a promising option to improve their prognosis in certain settings [39]. However, in our environment, ECPR is not yet fully implemented. In our cohort, age was associated with the vital prognosis of patients admitted after an aborted SCD, being also a determining factor in the management and treatment of these patients. Elderly patients received less invasive treatment even though they did not present a worse clinical profile upon arrival at the hospital, which could determine, at least in part, their worse prognosis.

Fig. 1. General management and predictors of in-hospital mortality and poor neurologic outcomes. SCD: sudden cardiac death; CAG: coronary angiography; OHCA: out-of-hospital cardiac arrest; PAC: Pulmonary artery catheter; CPR: Cardiopulmonary resuscitation; ROSC: Recovery of spontaneous circulation.
5. Study limitations

This is a multicenter retrospective observational study with a large cohort of patients after aborted SCD. Our study carries several limitations inherent to observational studies. The main being the impossibility of establishing causality between the differences found in elderly patients with SCD and their worse prognosis. Second, we decided to set a high age cut-off point to clearly differentiate older patients, which caused a large difference in the number of patients in each group (1029 patients < 80 years vs 131 patients > 80 years). In addition, given that emergency medical services can limit the therapeutic effort, there could have been a selection bias among patients who were admitted to the hospital after a SCD (decision not to EI-VM or an earlier decision to end CPR in older patients if an effective rhythm is not achieved), thus selecting those patients with higher likelihood to have a good neurological outcome. Finally, the higher non-anoxic early mortality rate in the elderly conditioned a higher percentage of patients who died before CPC could be assessed which may also have influenced the evaluation of neurological outcomes between the groups.

6. Conclusions

In conclusion, the present study shows that age plays an important role in the management and prognosis of patients admitted at CICU with an aborted SCD. A less invasive treatment of the elderly in this context could lead to an excess of mortality in these patients which would condition their worse outcomes. As the neurological prognosis of elderly patients who survive hospital admission seems to be comparable to that of younger patients, age itself should not be a reason to change the guidelines-based management of these patients. Further studies are needed to elucidate how a more invasive management of elderly patients admitted with an aborted SCD could improve their vital and neurological prognosis.

CRediT authorship contribution statement

Jordi Sans-Rosello: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. Maria Vidal-Burdeus: Conceptualization, Project administration, Data curation, Supervision, Validation. Pablo Loma-Osorio: Conceptualization, Data curation, Supervision, Validation. Alexandra Pons Riverola: Conceptualization, Data curation, Supervision, Validation. Nabil El Ouaddi: Conceptualization, Data curation, Supervision, Validation. Albert Araizo Solé: Conceptualization, Data curation, Supervision, Validation. C. Clarens, S. Beesems, G. Cebula, V.H. Correia, D. Cimpoesu, V. Raffay, S. Trenkler, A. Markota, A. Strömöe, R. Burkart, S. Booth, L. Bossaert, Survival after out-of-hospital cardiac arrest in Europe - Results of the EuReCa TWO study, Resuscitation. 148 (2020) 218–226.

References

[1] S.G. Priore, C. Blomström-Lundqvist, A. Mazzanti, N. Blom, M. Borggreve, J. Camm, P.M. de Lijfer, D. Fitzsimons, R. Holm, R. Hatala, G. Hindricks, P. Kirchhof, K.-H. Kuck, A. Hernandez-Madrid, N. Nikolau, T.M. Norekvi, C. Spaulding, D.J. Van Veldhuisen, 2015 ESC Guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death the Task Force for the Management of Patients with Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death of the European Heart Journal. Eur. Heart J. 36 (41) (2015) 2973–2986.

[2] A. Kumar, D.M. Avishay, C.R. Jones, J.D. Shaikh, R. Kaur, A. Aljadah, A. Kichloo, N. Shiwalker, S. Keshavamurthy, Sudden cardiac death: epidemiology, pathogenesis and management, Rev. Cardiovasc. Med. 22 (11) (2021) 1-77.

[3] H. Flaatten, D.W. de Lange, A. Artiga, D. Bin, R. Moreno, S. Christensen, G. M. Joyal, S.M. Bagshaw, C.L. Sprung, D. Benoit, M. Soares, B. Guidet, The status of intensive care medicine research and a future agenda for very old patients in the ICU, Intensive Care Med. 43 (9) (2017) 1319–1327.

[4] M. Winther-Jensen, M.N. Christensen, C. Hassager, L. Keber, C. Torp-Pedersen, S. M. Hansen, F. Lippert, E.F. Christensen, J. Kjærgaard, C. Andersen, Age-specific trends in incidence and survival of out-of-hospital cardiac arrest from presumed cardiac cause in Denmark 2002–2014, Resuscitation 152 (2020) 77–85.

[5] T. Tagami, H. Tanaka, S.D. Shim, M.-M. Ma, P.-i. Ko, S. Karim, P. Khurshakarnchana, G.Y. Naro, M.E.H. Ong, Impact of population aging on the presentation of out-of-hospital cardiac arrest in the Pan Asian Resuscitation Outcomes Study, Acute Med. Surg. 7 (1) (2020).

[6] J.-T. Grazer, J. Wennt, J. Herlitz, G.D. Perkins, R. Lefering, I. Tjelmeland, R. W. Koster, S. Masterson, F. Rossiell-Oritz, H. Maurer, B.W. Böttiger, M. Moerdl, P. Mols, H. Alhodizii, I. Hadzibegovic, M. Ioanides, A. Trublat, M. Wissgren, A. Sala, J. Escunaira, N. Nikolau, E. Nagy, B.S. Jonsson, P. Wright, F. Semeraro, C. Clarenz, S. Beesems, G. Cebula, V.H. Correia, D. Cimpoesu, V. Raffay, S. Trenkler, A. Markota, A. Strömöe, R. Burkart, S. Booth, L. Bossaert, Survival after out-of-hospital cardiac arrest in Europe - Results of the EuReCa TWO study, Resuscitation. 148 (2020) 218–226.

[7] T. Kitamura, S. Morita, K. Kiyohara, C. Nishiya, K. Kajino, T. Sakai, T. Nishitsuchi, Y. Hayashi, T. Shinzuma, T. Iwami, Trends in survival among elderly patients with out-of-hospital cardiac arrest: a prospective, population-based observation from 1999 to 2011 in Osaka, Resuscitation 85 (11) (2014) 1432–1438.

[8] N. Lerolle, L. Tringaud, H. Bornstain, J.-M. Tatot, A. Imbert, J.-L. Dieh, J.-Y. Fagon, E. Gueriot, Increased intensity of treatment and decreased mortality in elderly patients in an intensive care unit over a decade, Crit. Care Med. 38 (5) (2010) 59–64.

[9] N. Vargas, L. Tibullo, E. Landi, G. Carifi, A. Pireno, A. Pipp, I. Alviggi, R. Tizzano, E. Salzano, F. Di Giereza, M. Vargas, Caring for critically ill older patients: a critical review, Aging Clin. Exp. Res. 29 (5) (2017) 833–845.

[10] A. Boumondelli, P. Aegerter, B. Guidet, Treatment intensity and outcome of patients aged 80 and older in intensive care units: A Multicenter Matched-Cohort Study, J. Am. Geriatr. Soc. 53 (1) (2005) 88–92.

[11] G.D. Perkins, J.-T. Grazer, F. Semeraro, T. Olavsenveen, J. Soar, C. Lott, P. Van de Voorde, J. Marad, D. Zidenan, S. Mentzelopoulos, L. Bossaert, R. Greif, K. Monsieurs, H. Svavarssdottr, J.P. Nolan, S. Ainsworth, S. Akin, A. Alfonzo, J. Andre, S. Andzaita Montaito, A. Barilii, M. Baulin, B. Behringer, B. Bein, D. Blaert, R. Bingham, M. Blom, A. Boccuzzi, V. Borra, L. Bossaert, B.W. Böttiger, J. Brevickwoldt, O. Brissaud, R. Burkart, A. Cariou, P. Carifi, C. Parmazon, C. Canagahn, K. Couper, T. Cronberg, E. De Buck, N. De Lucas, A. De Rouvere, C. Deinzel, J. Delchol, B. Denis, J. Djakow, T. Djarv, P. Druwe, G. Eldin, H. Ersdal, H. Friberg, T. Graesner, R. Greif, A. J. Handley, C. Hassager, K. Haywood, J.K. Helne, D. Hendrickx, J. Herlitz, H. Hojrup, F. Hofs, F. Antecrevi, G. B. Johannsdottir, G. Khaila, B. Klaassen, J. Koppl, U. Kreimeier, A. Kuzovlev, T. Lauritsen, G. Lilia, F. Lippert, A. Lockey, C. Lott, I. Lucic, M. Maas, I. Macnicone, J. Marad, A. Martinez-Mejias, S. Masterson, S.D. Mentzelopoulos, D. Meyran, K.G. Monsieurs, C. Morley, V.R.M. Moulaget, N. Mptos, N. Nikolau, J. Nolan, T.M. Olavsenveen, E. Oliver, P. Pap, T. Pellis, G.D. Perkins, L. Pfanzl, Knizacek, K. Pitches, K. Poole, V. Raffay, W. Renier, G. Ristagno, C.C. Roehr, F. Rossiell-Oritz, M. Rudiger, A. Sahl, L. Sanchez Santos, C. Sandroni, F. Sari, A. Scagpiatli, S. Schiller, J. Schleiber, S. Schauab, F. Semeraro, S. Schumann, E.M. Singletry, C. Skare, M.B. Skriffvans, M. Smyth, J. Soar, H. Svavarssdottr, T. Szaczra, F. Taccone, M. Tageldin Mustafa, A. Te Pas, K.C. Thies, I.B. M. Tjelmeland, D. Trevisanato, A. Truhlar, G. Trummer, N.M. Turner, B. Uffel, J. Uffel, J. Vaahersalo, P. Van de Voorde, H. Van Goor, L. Vaigl, S. Veldhuisen, 2015 ESC Guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death the Task Force for the Management of Patients with Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death of the European Heart Journal. Eur. Heart J. 36 (41) (2015) 2973–2986.
