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Clinical paper

Survival after out-of-hospital cardiac arrest in Europe - Results of the EuReCa TWO study

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Abstract

Background: The epidemiology and outcome after out-of-hospital cardiac arrest (OHCA) varies across Europe. Following on from EuReCa ONE, the aim of this study was to further explore the incidence of and outcomes from OHCA in Europe and to improve understanding of the role of the bystander.

Methods: This prospective, multicentre study involved the collection of registry-based data over a three-month period (1st October 2017 to 31st December 2017). The core study dataset complied with the Utstein-style. Primary outcomes were return of spontaneous circulation (ROSC) and survival to hospital admission. Secondary outcome was survival to hospital discharge.

Results: All 28 countries provided data, covering a total population of 178,879,118. A total of 37,054 OHCA were confirmed, with CPR being started in 25,171 cases. The bystander cardiopulmonary resuscitation (CPR) rate ranged from 13% to 82% between countries (average: 58%). In one third of cases (33%) ROSC was achieved and 8% of patients were discharged from hospital alive. Survival to hospital discharge was higher in patients when a bystander performed CPR with ventilations, compared to compression-only CPR (14% vs. 8% respectively).

Conclusion: In addition to increasing our understanding of the role of bystander CPR within Europe, EuReCa TWO has confirmed large variation in OHCA incidence, characteristics and outcome, and highlighted the extent to which OHCA is a public health burden across Europe. Unexplained variation remains and the EuReCa network has a continuing role to play in improving the quality management of resuscitation.

Keywords: Out-of-hospital cardiac arrest, European registry of cardiac arrest, Bystander CPR, Outcome after OHCA, Resuscitation

Introduction

Sudden out of hospital cardiac arrest (OHCA) is the third leading cause of death in Europe.[1] The first European Registry of Cardiac Arrest project (EuReCa ONE) collected and analysed data across Europe on resuscitation events during October 2014. This revealed that more than half of patients with OHCA who are assessed by the Emergency Medical Services (EMS) received cardio-pulmonary resuscitation (CPR) either before or on arrival of the EMS.[1] Among such cases, survival to 30 days reached approximately 10%.[1] However, in previous studies covering European areas high survival rates are reported.[2,3]

There are a number of well-known factors that influence outcome after OHCA.[4] The majority of these studies have shown that early initiation of CPR, and increased use of Automated External Defibrillators (AEDs) is associated with an improved chance of survival.[3,5–9] While previous studies have tried to fill the knowledge gap regarding the OHCA epidemiology of cardiac arrest in Europe,[1,10,11] EuReCa ONE was the first attempt to study OHCA epidemiology on a European scale, but data collection was limited to one month. The aim of EuReCa TWO is to further explore the epidemiology of OHCA by tripling the observation period (to three months), expanding the reach of the EuReCA network by involving more countries, and gaining a better understanding of the role of the bystander in a cohort of the population in 28 European countries.

Material and methods

EuReCa TWO was an international, prospective, multi-centre study, for which data were collected from 1st October 2017 to 31st December 2017. Patients with OHCA were eligible for inclusion if they were attended by EMS regardless of performance or non-performance of a resuscitation attempt, arrest aetiology, initial arrest rhythm, age, or gender. The core

study dataset complied with the Utstein definitions.[12] In addition to the EuReCa ONE dataset, the following study questions were added: age and gender of the bystander; date and time of arrival at scene; and death on scene (EuReCa TWO full dataset, Supplemental Table S1).

European registries that were able to provide at least the core data demanded in the dataset, were invited to participate in EuReCa TWO. Each participating country was represented by a National Coordinator (NC), who was responsible for ensuring consistency and uniformity of data to obtain comparable results across countries.[13] National datasets of patient-level anonymised data were uploaded onto a password-protected area of the EuReCa website, after which they were checked for completeness and logical errors. Results were then sent back to the NCs for final confirmation.

The EuReCa TWO study is registered with ClinicalTrials.gov (Registration Number: NCT03130088).

Statistical analysis

Incidence rates for three months were calculated using the population covered, and extrapolated to incidence rates per 100,000 population per year. Descriptive analyses of patient demographics, case characteristics, bystander characteristics, treatment, and outcome variables were performed for the whole group and for each participating country. Outcome was described in a nested number of subgroups. Survival was derived from the status at 30 days, or hospital discharge. At each level of analysis some cases with missing information were excluded from subsequent analyses (Fig. 1). Supplemental Table S2 shows details of the proportion of missing cases.

Continuous variables were presented with mean and standard deviation (SD), or range and median with interquartile range (IQR). For selected variables 95% confidence intervals (CI 95) were calculated based on the Poisson distribution, specifically for national data based on a varying sample size.

Role of the funding source

The EuReCa TWO study was funded by the European Resuscitation Council (ERC) and the national resuscitation registries and institutes conducting the study. Funding for running the central data base and meetings of the Study Management Team was provided by the German Resuscitation Registry. The funding organisations had no influence on the data analysis or preparation of the manuscript.

Technical and administrative support was provided by the Study Management Team. Members of the Scientific Committee had full access to the study data.

Results

In the 28 participating European countries, data from regions covering 178,879,118 inhabitants were reported (Supplemental Table S3). Four countries reported data for the whole country while others

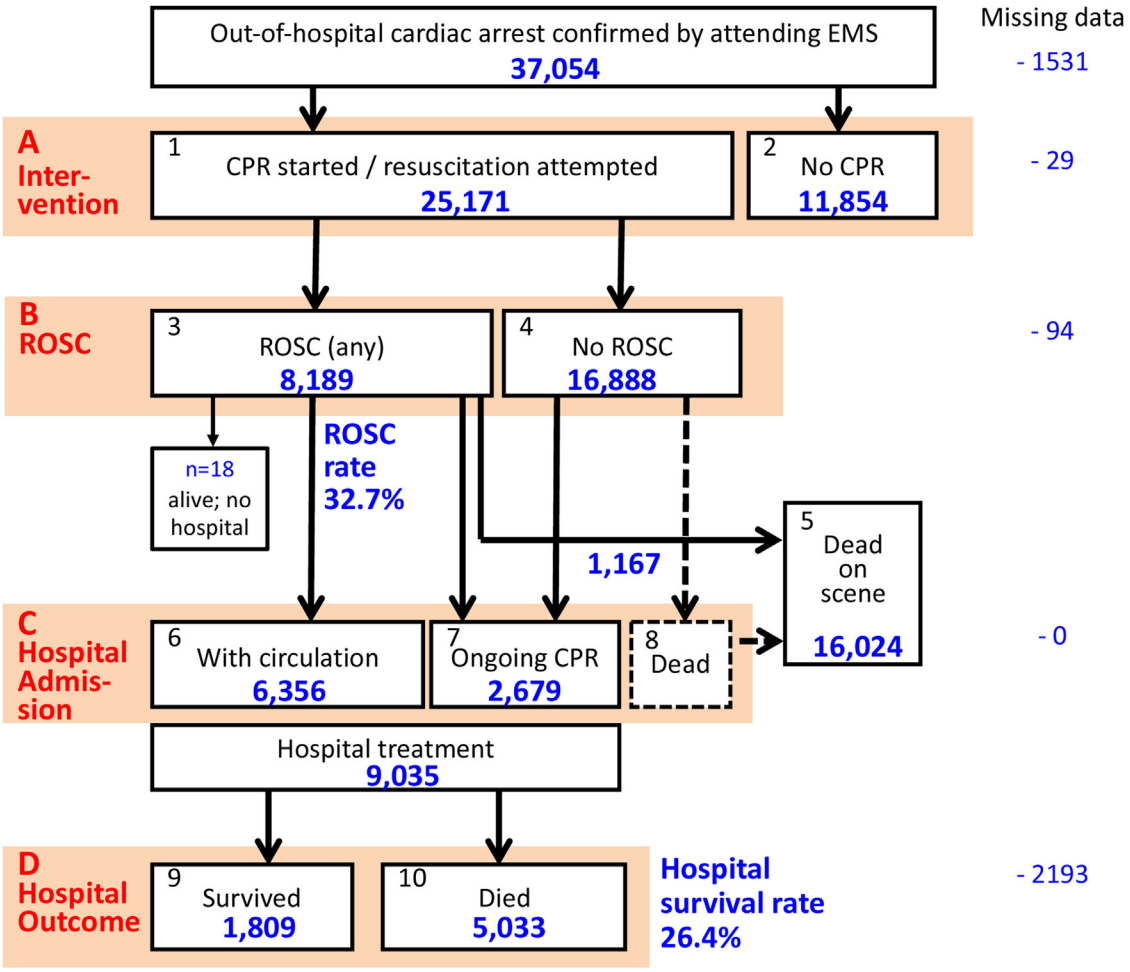

Fig. 1 – Flow diagram of all patients in the study.

Table 1 – Patient and system factors: variation across countries.

	No. of countries	No. of cases	Overall average	Median of country values	Range of country values
Cases with CPR attempted (if CA was confirmed)	28	25,171	899	440	22–3842
Mean age (years)	28	24,687	67.6	67.3	55.8–75.4
Male gender (%)	28	25,078	65.4	65.9	53.4–73.3
Medical/cardiac cause (%)	28	22,927	91.1	91.1	70.0–100
Traumatic cause (%)	28	957	3.9	3.4	0–8.0
Location: residence (%)	28	15,638	70.2	68.9	51.0–81.3
Telephone CPR (%)	24	11,238	53.2	37.3	3.2–87.8
Collapse witnessed (%)	28	15,824	66.6	66.5	50.8–91.8
Bystander CPR (%)*	28	12,445	58.0	57.6	13.0–82.6
Shockable rhythm (%)	28	4,792	20.2	19.2	11.4–36.8
ROSC (%)	28	25,077	32.7	29.7	6.9–43.3

covered from 3% to 94% of the total population. There were 38,585 suspected cardiac arrests reported of which 37,054 were confirmed. In 25,171 patients, resuscitation was started by a bystander or by the EMS. The proportion of cases where resuscitation was commenced or continued by the EMS was 62.6%, ranging from 41% to 97% (Supplemental Table S2). Three countries reported only patients for whom resuscitation was started. The mean incidence rate of started resuscitations was 56 per 100,000 population per year, (range 27–91 per 100,000 population per year). Mean and median values and range of values between countries of important patient and system characteristics are shown in Table 1.

Patient characteristics

The mean age of the patients where resuscitation was started was 67.6 (SD 17.5) years, range 0–107 years (age distribution in Supplemental Fig. S1), and 65% of patients were male (range 53% –73%). Of those for whom CPR was not started, mean age was 71.5 years (SD 17.4). Between countries, the mean age where CPR was started ranged from 56 years to 75 years.

The aetiology and location of the cardiac arrest is summarised in supplemental Table 4. A presumed medical aetiology was reported in 91.1% of all cases. Most patients (70.2%) were at home or in a residence at the time of collapse. "School building" was documented as a location in ten countries, and less than five patients of the 23 cases with a cardiac arrest in schools were less than 17 years of age.

Witness and bystander CPR

Data on witness status was available for 94% of cases where CPR was started. Bystanders initiated CPR in 58% of cases (ranging from 13% to 82%, Supplemental Fig. S2). When CPR was started by a bystander, the rate of return of spontaneous circulation (ROSC) and overall survival to hospital discharge was better than when CPR was initiated by either a person sent to help or by the EMS (Table 2. Six countries with 4,503 cases did not report on the type of bystander CPR. Of the countries that reported this, data from 1,777 22%) cases were missing. Of the cases for which the type of CPR was reported, 72% received chest compression only CPR and the others received chest compressions and ventilations. Those who received both chest compressions and ventilations had a significantly better survival to hospital discharge than those who only received chest compressions (14% vs. 8%; $p < 0.001$).

Table 2 – Who started CPR?

Group	N	ROSC	Survival
Bystander CPR	12,445	32.3%	9.1%
CC only	4,437	25.9%	7.7%
full CPR	1,728	37.1%	13.6%
unknown*	1,777	31.7%	8.1%
countries without these data**	4,503	37.0%	9.0%
No bystander CPR	9,003	28.2%	4.3%
Person sent to help	2,420	22.7%	3.9%
EMS started CPR	6,583	30.2%	4.5%

* Of the countries that supplied data on type of CPR.

** These countries were not able to supply this information: BH, DE, DK, IE, NO, UK.

Age and gender of the patient and the rescuer was known in 31% of cases where bystander CPR was performed. In these cases 70% of patients and 57% of rescuers were males and their mean age was 66 and 47 years, respectively. In 84% of cases the rescuer was younger than the patient, but only a small minority of rescuers were younger than twenty years. In approximately one-fifth of the cases where cardiac arrest occurred at home, CPR was performed by a person of the opposite sex and of a similar age (Fig. 2).

Rhythm and defibrillation

The initial recorded rhythm was reported in 23,750 cases (94.4% of all cases. Of these, 4,792 (20%) had an initial shockable rhythm (range between countries 11%–37%, Supplemental Fig. S3). Date and time of the first shock was available for 2,804 patients with an initial shockable rhythm in whom CPR was started. The median time from call to first shock was 11 min IQR 7–16 min; Supplemental Fig. S4).

Outcomes

The outcomes of resuscitation are shown in Fig. 1. The overall mean ROSC rate before transport was 33%, ranging from 8% - 42% (Supplemental Fig. S5).

In patients where CPR was performed by EMS, 25% of patients were transported with ROSC, 11% were transported with ongoing CPR, and 64% were dead on scene and not transported to hospital (Fig. 1).

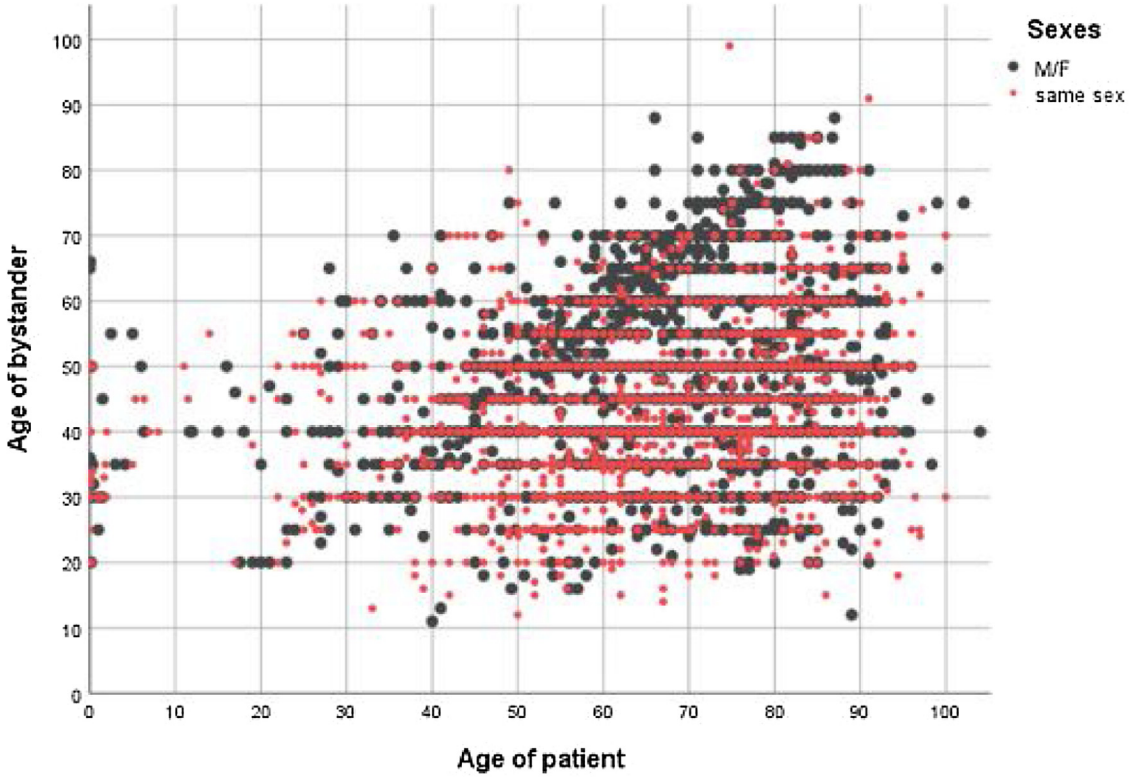

Fig. 2 – Age distribution of pairs of patients and rescuers performing bystander CPR, in the 3818 cases (30.7% of all cases of bystander CPR) where age and sex of both was known. Each dot represents a pair of a patient with its rescuer. Pairs in which patient and rescuer have opposite sex are black dots (623 cases), otherwise red dots 3,195 cases. The age of the patient is known with a year precision, the age of the rescuer is estimated with an precision of, mostly, 5 years.

Return of spontaneous circulation occurred in 58% in the shockable rhythm group and 26% in the non-shockable group. Overall survival to hospital discharge was 24% in the shockable group and 3% in the non-shockable group respectively.

For all patients for whom CPR was initiated and for whom survival status was available, 8% survived to hospital discharge (range 0% –18%, Fig. 3). Of the patients who were transported to hospital and for whom survival status was known, hospital survival was 26%, ranging between 0% and 48%, (Supplemental Fig. S6). Of those admitted with ROSC, 35% were discharged alive. Of those admitted with ongoing CPR 4% were discharged alive.

The criteria of the Utstein comparator group (cardiac arrest witnessed by a bystander, and having initial shockable rhythm) were fulfilled in 13% of cases (range 6%–27%; data excludes countries with <10 cases). The rate of ROSC for this subgroup was 59% (range 30% –81%, Supplemental Fig. 6) while the overall survival to hospital discharge was 789 of 2,827 patients for whom hospital survival status was known (i.e. 28%; range 0%–53%, Fig. 4).

Discussion

The EuReCa TWO study prospectively describes the epidemiology of OHCA and the effects of CPR before EMS arrival in 28 countries in Europe. By increasing the number of participating countries and the duration of data collection, this study has further confirmed large variation in European estimates of OHCA incidence and outcome. EuReCa TWO has also demonstrated the potential of 28 countries to collect OHCA data covering almost 180 million inhabitants, fulfilling a central aim of the EuReCa project to build a network of people across Europe with an interest in quality management in resuscitation.[11]

The overall incidence of OHCA where CPR was attempted was 56 (range: 21–91) per 100,000 population per year. In the EuReCa ONE study, the corresponding figure was 49 per 100,000 population per year, (range between 19 and 104).[1] From an international perspective, this figure is similar to the overall incidence of EMS attempted resuscitation reported by Beck et al. from the AusROC epistry (47.6 per 100,000 population in 2015).[14] The EuReCa incidence estimate is also close to that reported for the United States from the CARES registry in 2013, (56.9 per 100,000), however the CARES estimate included only non-traumatic arrests that had an EMS resuscitation attempt.[15] EuReCa incidence is somewhat lower than reported by Okubu et al. for the Japanese population in 2014, but this difference is assumed to be due to the fact that resuscitation is started more often in Japan.[16] Overall survival in all cases where CPR was attempted was 8%, compared to 10% in EuReCa ONE.[1] Among the patients in the Utstein comparator group, survival to hospital discharge was similar (30% in EuReCa ONE vs. 31% in EuReCa TWO respectively).

In common with EuReCa ONE, there was again large variability between countries in terms of incidence rate, patient characteristics and outcomes. For example, the proportion of patients who were

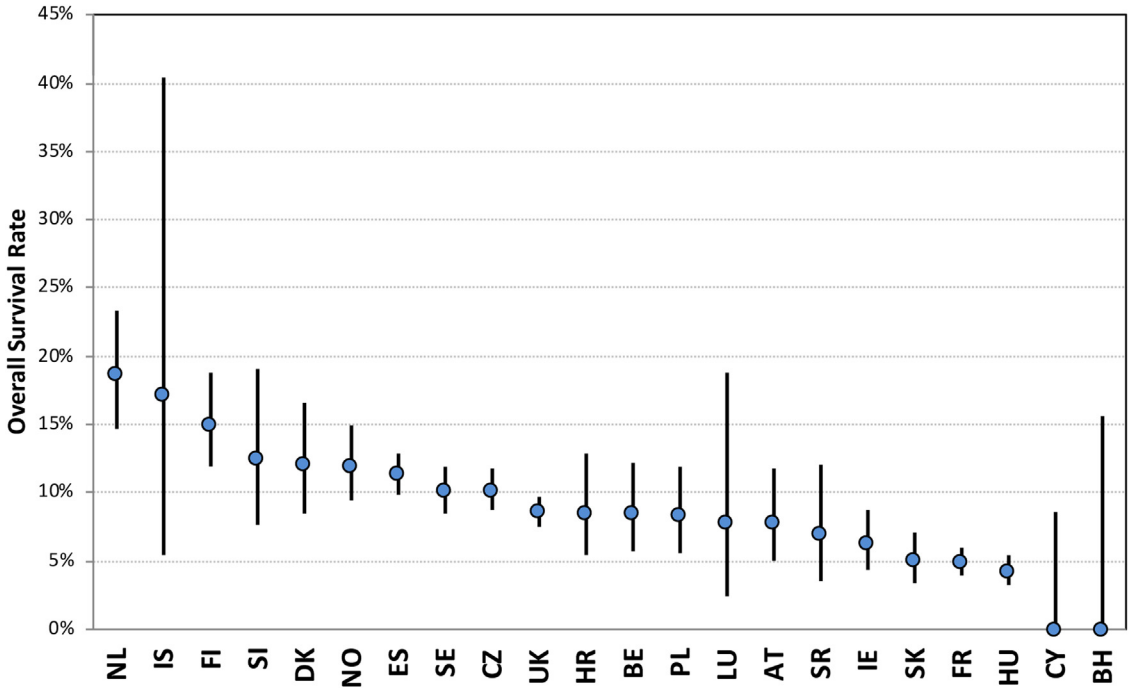

Fig. 3 – Survival rate for patients for whom CPR was started. Data points are mean values and bar indicates 95% confidence interval. Countries with >25% missing outcome data were excluded (IT, GR, PT, DE, CH, RO); n = 17,798. Country codes are specified in Supplemental table 3.

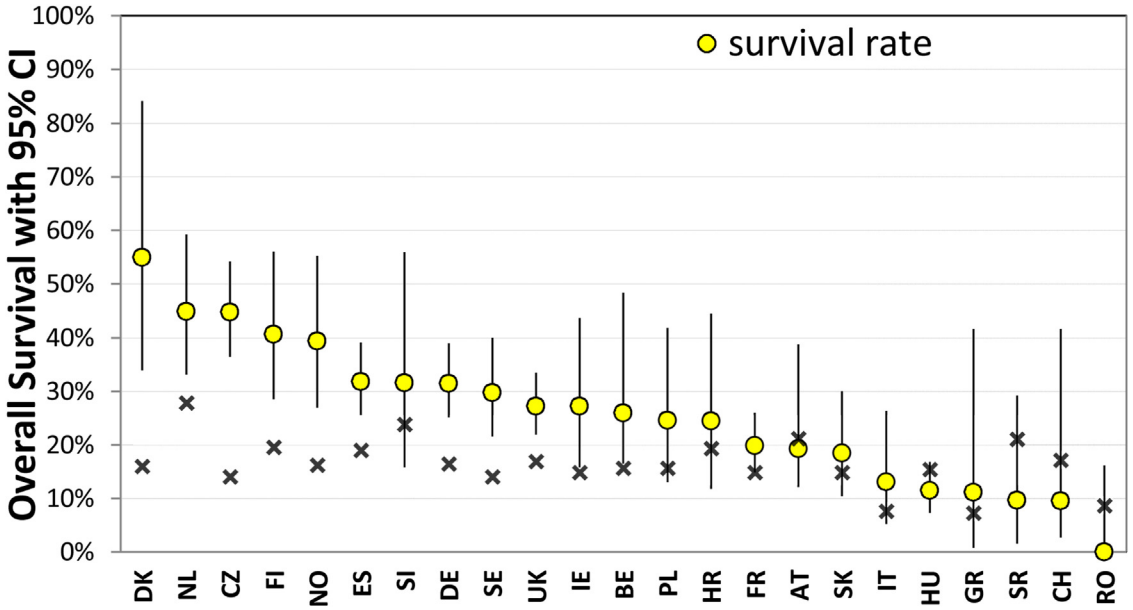

Fig. 4 – Utstein comparator group: overall survival. Bars indicate 95% confidence interval. X indicates prevalence of Utstein comparator status among all patients with started resuscitation. Countries with <10 cases were excluded (BH, IS, CY, PT).
Country codes are specified in Supplemental table 3.

found in ventricular fibrillation varied between 11% and 37%. Survival to hospital discharge differed markedly between countries among all patients. In the Utstein comparator group, survival ranged from 0% to 50%, where 0 % may be explained by a low sample size. Differences in terms of bystander resuscitation, EMS system effectiveness, hospital treatment, culture and attitude towards CPR may all contribute to this variation.[17] The variability in terms of characteristics and outcome that was found in both EuReCa studies has also been demonstrated from an international perspective but with slightly higher overall survival than in EuReCa TWO.[18] The increased sample size of EuReCa TWO

reduces variation by chance in national estimates, but confirms large variation across countries in Europe. This variation needs a closer analysis of factors not covered by the actual data collection, for example different cultural approaches to cardiac arrest, availability of EMS support in rural and urban regions, or public awareness. Understanding these striking differences is an important task, and requires further detailed analysis beyond the scope of this paper.

Twenty percent of patients in the EuReCa TWO study were found in a shockable rhythm. In an earlier study, Cobb et al. and Hulleman et al. reported a decreasing incidence in shockable rhythm from different countries in Europe and the US.[19,20] Considering that programs with public access defibrillation have found higher percentages of VF, and that the median delay from call for EMS until shock delivery in our study was eleven minutes, this highlights enormous potential for system improvements.[21,22]

CPR was started before arrival of EMS in 58% of the cases. This proportion has increased since the EuReCa ONE study (48%).[1] However, this apparent increase in bystander CPR has not been accompanied by a significant increase in survival to hospital discharge (8%), and highlights the importance of a precise definition of bystander CPR. In order to further understand how the term "Bystander CPR" is used in EMS across Europe a cross-sectional study was conducted, which showed that the interpretation of the term varied, particularly where community response systems had been established.[23] An updated and uniform definition of bystander CPR is therefore needed. As our data collection methodology did not distinguish between AED use by bystanders, first responders and the EMS, this impacted the analysis of the contribution of AEDs to the treatment of OHCA. The increasing use of AEDs before EMS arrival also created an important potential bias in outcome reporting: in the Utstein template for OHCA "resuscitation attempted" is defined as EMS personnel performing chest compressions or attempt defibrillation. Of 693 patients who had signs of life on arrival of EMS, 45 had received AED shocks before EMS arrival and were classified as "not confirmed by attending EMS" in compliance with the Utstein recommendations. This is highlighted by a study from the Copenhagen-Oslo-STockholm-Amsterdam (COSTA) study group, who showed that of all survivors in their study with a known defibrillation status (n = 2,957), 454 (20%) were defibrillated by a first responder AED and 429 (19%) were defibrillated by an onsite AED.[24]

In cases with bystander CPR "chest compression only" CPR was performed in 72% of cases. Recent studies indicate that "chest compression only" is becoming increasingly common when CPR is performed by a bystander.[25,26] However, our study indicates that percentage survival is higher when full CPR is performed compared to chest compression only CPR. Since no adjustments were made for potential confounders, caution in the interpretation of these data is advised, particularly as previous registry data has shown different results regarding the association between the type of bystander CPR and the chance of survival.[26]

As shown in Fig. 2, there appears to be an interesting clustering of similar age and opposing sex between victim and rescuer. This suggests that the age and gender relationship observed between victim and rescuer is beyond chance. In the majority of other cases the bystander performing CPR was younger than the victim and predominantly male. While the value of training young people in school is not to be underestimated, our findings also indicate that advocating cardiac arrest awareness and CPR training in persons of the expected age of potential cardiac arrest victims is important.

On a European level, our results reinforce previous findings by highlighting the value of bystander CPR in that the rate of survival to hospital discharge among all patients in whom CPR was started by a bystander was twice as high as when CPR was started by a person sent to help or by EMS. It is also of note that patients in whom CPR was never started were four years older than those in whom CPR was started. While it is acknowledged that our dataset did not include information on pre-existing co-morbidities or circumstances of arrest, age is an independent predictor of OHCA survival, but advanced age is not a criterion for withholding a resuscitation attempt.[27]

Limitations

The limitations of registry studies are well known and have been previously described.[13] EuReCa TWO gathered information from European EMS systems with very different characteristics. Additionally, some of the contributing registries reported only OHCA with resuscitation attempts or reported data covering only a proportion of the population, which affects the ability to compare incidence across countries.

In the analysis of the type of bystander CPR given, information from 50% of all cases was not available or reported unknown. This raises the concern of reporting bias. However, as Table 2 shows, the majority of cases for which bystander CPR was reported were from countries that did not report on the type of bystander CPR, which will not cause bias. Survival of these cases is similar (8.1% and 9.0%) to the overall survival of those in which this information was known (9.1%). This suggests that reporting bias was unlikely or not important.

EuReCa TWO was carried out over the months of October to December that have been associated with higher than the year's mean incidence of cardiac arrest.[28] It is possible that seasonal variations may have influenced data collection, incidence estimates and final results.[13] Additionally, EuReCa TWO did not include data on in-hospital patient management. Both targeted temperature management and percutaneous coronary intervention have shown convincing evidence on their influence in survival after OHCA and data on the availability and performance of these interventions was not obtained in the present study.[29,30] Finally, the volume of missing data – particularly for core Utstein variables – may indicate quality issues in OHCA data collection systems.

Conclusion

EuReCa TWO has reinforced the large public health burden of OHCA in Europe, while highlighting the variability in incidence and survival. In addition, EuReCa TWO has added findings in relation to the performance of bystander CPR in Europe. It highlights the need for further work on the definition of this important predictor of outcome. Between-country variation remained an incompletely understood feature of our results. Continued collaboration across the EuReCa network will help to elucidate differences through continued focus on the importance of quality of data collection for quality management of resuscitation.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.12.042.

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