

# How Unexpected Is Out-of-hospital Sudden Cardiac Arrest? A Retrospective Cohort Study

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## Original research

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# Abstract

## Background

Approximately 100,000 patients suffer from sudden cardiac arrest (CA) annually in Germany. The causes for CA are cardiac in 75% of these cases. The present study aims to investigate the medical prehistory of patients who suffered from out-of-hospital cardiac arrest (OHCA) in a town with 250,000 inhabitants during 5 years and how many of these patients had already been previously treated at the local cardiac arrest center (CAC).

## Case presentation

All resuscitations due to OHAC were retrospectively analyzed for the cause of OHCA, preexisting cardiac conditions and treatment, lay resuscitation, and outcome from January 1, 2012, to December 31, 2016, in Aachen, Germany. Data analysis was based on the resuscitation protocols and data from the CAC clinical information system.

More than 50% of the patients with CA from cardiovascular origin were already known at the receiving respective CAC. Almost 60% of all patients already had cardiac preexisting conditions. Nevertheless, lay resuscitation occurred in only 34.1% of all cases. It was not performed in more than 60% although the probability of discharge can be significantly increased by lay resuscitation.

## Conclusion

The rate of lay resuscitation is relatively low although many patients suffering from CA have cardiac preexisting conditions. These findings show the importance of better priming their relatives for emergencies to improve lay resuscitation and improve the chances for a better outcome.

## Background

More than 350,000 patients suffer out-of-hospital cardiac arrest (OHCA) in Europe annually (1), and more than 100,000 in Germany alone (2). Estimates suggest that only about 10% of all patients survive an OHCA despite the recent advances and improvements in the standard of care for periarrest patients (3, 4). The EURECA One study also showed a 10.3% survival rate for at least 30 days (5). Those few patients surviving OHCA are often discharged with increased morbidity and poorer quality of life (6, 7) after a lengthy and costly hospital stay (8–10).

The majority of adult cardiac arrests (CA) occurs because of cardiac reasons (11–13). About half of all cardiovascular mortalities worldwide are caused by sudden cardiac death (14). In most cases, patients suffering from sudden cardiac arrest had coronary heart disease before cardiac arrest (15). Therefore, it is likely that the majority of patients who suffer from OHCA have already been suffering from preexisting cardiac disease. The outcome after OHCA is poor. Thus, this study aims to find out how many patients with OHCA had preexisting conditions and have already been hospitalized before the onset of circulatory

arrest. This knowledge could offer the possibility of identifying risk patients more easily and may offer the chance for an intervention to increase the probability of survival. In Germany, for example, OHCA is witnessed by laypersons in about 55% when not occurring in the presence of medical professionals. However, the rate of lay resuscitation by witnesses is still as low as 42% (16, 17). Moreover, several campaigns, e.g., the German “Resuscitation Week,” have tried to encourage the population to perform sufficient lay resuscitation (18, 19).

The primary aim of this study was to estimate the proportion of patients with OHCA who were already known to the responsible cardiac arrest center (CAC) beforehand. The secondary aims were to measure the proportion of lay resuscitations and the outcomes of these patients. Therefore, a retrospective analysis of OHCA cases treated by the Aachen Emergency Medical Service (EMS) was conducted and the clinical data from the responsible CAC were matched.

## Methods

### Patients

The appropriate ethics committee waived the requirement for informed consent and granted permission to the EMS Medical Director to retrospectively analyze patient data (EK109/15). All out-of-hospital cardiopulmonary resuscitations (CPRs) between January 1, 2012, and December 31, 2016, conducted by the City of Aachen (Germany) EMS were eligible for inclusion.

All patients suffering OHCA in Aachen are usually hospitalized in the University Hospital of Aachen as the only local CAC. Patients who were resuscitated owing to noncardiac causes were excluded from the study.

### Data sources and variables

As a member of the German Resuscitation Registry ([www.reanimationsregister.de](http://www.reanimationsregister.de)), the City of Aachen EMS collects data of all out-of-hospital resuscitation patients in the requested standardized format based on the Utstein template. For this analysis, the respective data were used and complemented with data from the original emergency mission protocols and hospital records abstracted by using the names, dates of birth, dates of resuscitation and admission times, and patient data from the local CAC, including administrative data, diagnoses codes, previous medical history, discharge letters, and neurological outcome (cerebral performance category [CPC]). Information about medical history was also taken from emergency mission protocols to complete existing hospital records or only as data source. The reason for OHCA and its compatibility with preexisting conditions were also evaluated. All of the aforementioned sources were used to complete the preresuscitation information of the patients concerning their medical history of preexisting conditions. Using the above data sources, the number of previous hospital admissions, admission reasons, and preexisting conditions were categorized at the discretion of the investigator.

## Statistical methods

All analyses were exploratory. Data were analyzed with GraphPad Prism 8 (GraphPad Software, San Diego, CA, USA). Categorical and continuous data were compared using the exact Fisher's test and Student's *t*-test. The probability of a type I error  $< 0.05$  was considered statistically significant.

## Results

### Patients

During the study period, 904 patients were resuscitated by the EMS of the City of Aachen. After excluding 309 cases of OHCA due to noncardiac reasons and 67 cases with missing data (patients unidentifiable), 528 cases of cardiac-related OHCA were analyzed (Fig. 1). Patients were mostly male (65.5%) and had a median age of 74 years (interquartile range [IQR], 61–82). Return of spontaneous circulation (ROSC) could be established in 42.3% of the patients ( $n = 226$ ). The characteristics of the study population are depicted in Table 1.

Table 1

Characteristics of the study cohort (528 patients treated for out-of-hospital cardiac arrests by the City of Aachen Emergency Medical Service between 2012 and 2016).

	Median	[IQR], n (%)
Age, years	74.0	[61.0–82.0]
Gender		
Female	182	(34.5)
Male	346	(65.5)
Begin of CPR		
Latency unknown	291	(55.1)
Latency-free resuscitation	153	(29.0)
Latency <sup>a</sup> , min	6,5	[5–10]
Begin of CPR by lays	180	(34.1)
CPR		
Duration of resuscitation <sup>b</sup> , min	25	[15–39]
Application of mechanical resuscitation device	124	(23.5)
Application of intraosseous line	93	(17.6)
Return of spontaneous circulation <sup>c</sup>		
Never ROSC <sup>c</sup>	294	(56.2)
Ever ROSC <sup>c</sup>	225	(43.0)
Handover to hospital with CPR <sup>d</sup>	93	(17.8)
Handover to hospital with ROSC <sup>d</sup>	194	(37.2)
Ambulance mission times		
Mission alert ambulance, <sup>e</sup> min	6	[4–7]
Mission alert EMS physician, <sup>f</sup> min	7	[5–9]
On-scene arrival to handover hospital, ambulance, <sup>g</sup> min	48	[38–58]
On-scene arrival to handover hospital, EMS physician, <sup>h</sup> min	46	[36–55]
Alert of ambulance until handover in the hospital, <sup>i</sup> min	54	[44.0–64]

	Median	[IQR], n (%)
Alert of EMS physician until handover in the hospital, <sup>j</sup> min	53	[43–62]
Destination of transport		
University cardiac arrest center	259	(88.4)
Other hospital	34	(11.6)
<sup>a</sup> Latency to start of resuscitation (> 0) in 84 cases		
<sup>b</sup> Data known in 406 cases		
<sup>c</sup> Data known in 520 cases		
<sup>d</sup> Data known in 522 cases/in four cases no information referring ROSC		
<sup>e</sup> Data known in 491 cases		
<sup>f</sup> Data known in 498 cases		
<sup>g</sup> Data known in 201 cases		
<sup>h</sup> Data known in 260 cases		
<sup>i</sup> Data known in 262 cases		
<sup>j</sup> Data known in 262 cases		
<i>CPR</i> cardiopulmonary resuscitation, <i>ROSC</i> return of spontaneous circulation		

### Prior medical contact at the local cardiac arrest center

Of the 528 patients with cardiac-caused OHCA, 282 (53.4%; 95% confidence interval (CI), 49.1–57.7%) had received prior medical attention at the local university CAC, which is a hospital with special certification for the treatment of patients after OHCA (20). No admission diagnosis is documented in 46 cases. More than one-quarter of these patients with an admission diagnosis (69 of 236, 29.2%; 95% CI, 23.8–35.4%) were admitted because of cardiac conditions (Fig. 2). Patients admitted because of cardiac conditions were hospitalized 0.87 (0.24–4.08) years before OHCA. Furthermore, 37 of 69 patients (53.6%; 95% CI, 42.0–64.9%) were admitted within 1 year before OHCA. The second most frequent reason for hospital admission were surgical conditions (48 of 236, 20.3%; 95% CI, 15.4–26.1%) followed by other medical conditions (37 of 236, 15.7%; 95% CI, 11.6–20.9%). Table 2 displays the admission diagnoses of those patients who were hospitalized before OHCA.

Table 2

Categorized admission diagnoses from 236 patients with prior contact at the local cardiac arrest center out of 528 cardiac-caused out-of-hospital cardiac arrests (in 46 cases there were no admission diagnoses documented).

Admission diagnoses <sup>a</sup>	<i>n</i> <sup>b</sup>	(%)
Cardiac conditions ( <i>n</i> = 69; 29.2%)		
Coronary artery disease <sup>d</sup>	13	(5.5)
Myocardial infarction <sup>d</sup>	13	(5.5)
Angina pectoris <sup>d</sup>	6	(2.5)
Cardiac arrhythmia	5	(2.1)
Hypertension	5	(2.1)
Cardiomyopathy	4	(1.7)
Acute coronary syndrome <sup>d</sup>	4	(1.7)
Valve defect	3	(1.3)
Other cardiac reasons	16	(6.8)
Pulmonary conditions ( <i>n</i> = 7; 3.0%)		
Pneumonia	5	(2.1)
COPD	2	(0.8)
Other medical conditions ( <i>n</i> = 37; 15.7%)		
Oncologic conditions	15	(6.4)
Gastroenterologic conditions	7	(3.0)
Nephrologic conditions	5	(2.1)
Endocrinologic/metabolic conditions	3	(1.3)
Syncope	3	(1.3)
Nonsurgical infections	4	(1.7)
Surgical conditions ( <i>n</i> = 48; 20.3%)		

<sup>a</sup>Entered to the patient data management system to the discretion of the emergency room physician; no admission diagnoses were entered for 46 patients

<sup>b</sup>Diagnoses with the frequency of *n* = 1 were aggregated to *others* within the respective category. The cardiac one was chosen in case of two admission diagnoses. Acute instead of chronic, systemic instead of local, was chosen if no cardiac was chosen.

Admission diagnoses <sup>a</sup>	<i>n</i> <sup>b</sup>	(%)
Trauma-related conditions	24	(10.2)
Wound care	8	(3.4)
Epistaxis	5	(2.1)
Fracture	4	(1.7)
Fall	4	(1.7)
Vascular conditions	3	(1.3)
Neurological or psychiatric conditions ( <i>n</i> = 20; 8.5%)		
Stroke	7	(3.0)
Myasthenia gravis	2	(0.8)
Epilepsy	2	(0.8)
Suicidal tendency	2	(0.8)
Other neurological or psychiatric conditions	7	(3.0)
Ophthalmologic conditions	17	(7.2)
Urologic conditions	14	(5.9)
Other conditions	24	(10.2)
<sup>a</sup> Entered to the patient data management system to the discretion of the emergency room physician; no admission diagnoses were entered for 46 patients		
<sup>b</sup> Diagnoses with the frequency of <i>n</i> = 1 were aggregated to <i>others</i> within the respective category. The cardiac one was chosen in case of two admission diagnoses. Acute instead of chronic, systemic instead of local, was chosen if no cardiac was chosen.		

### Preexisting conditions

Further analysis showed that 393 of the 528 patients (74.4%; 95% CI, 70.5–78.1%) with cardiac-caused OHCA already had diagnosed preexisting conditions (Table 3). Cardiocirculatory conditions were the most common preexisting conditions (327 of 393, 83.2%; 95% CI, 79.2–86.6%) followed by other medical conditions (130 of 393, 33.1%; 95% CI, 28.4–38.0%). The most common diagnoses were arterial hypertension (172 of 393, 43.8%; 95% CI, 38.8–48.8%) and coronary artery disease (107 of 393, 27.2%; 95% CI, 22.9–31.9%). Of the patients, 19 of 393 (4.8%; 95% CI, 2.9–7.5%) had an implantable cardioverter–defibrillator or pacemaker, and 10 of 393 (2.5%; 95% CI, 1.2–4.6%) had already been resuscitated. Furthermore, pulmonary diseases were preknown in 105 patients (26.7%; 95% CI, 22.6–31.3%).

Table 3

Categorized preexisting conditions from 393 patients with prior diagnoses out of 528 cardiac-caused out-of-hospital cardiac arrests.

<b>Preexisting conditions</b>	<b><i>n</i><sup>a</sup></b>	<b>(%)<sup>b</sup></b>
Cardiac conditions ( <i>n</i> <sup>a</sup> = 327; 83.2% <sup>b</sup> )		
Coronary artery disease	107	(27.2%)
Myocardial infarction	73	(18.6%)
Hypertension	172	(43.8%)
Cardiac arrhythmia	86	(21.9%)
Cardiomyopathy	24	(6.1%)
Acute coronary syndrome	10	(2.5%)
Valve defect	54	(13.7%)
Heart failure	51	(13.0%)
Pacemaker/cardioverter–defibrillator	19	(4.8%)
Stent	24	(6.1%)
Cardiogenic shock	1	(0.3%)
Cardiac decompensation	17	(4.3%)
Other cardiac reasons	148	(37.7%)
Pulmonary conditions ( <i>n</i> <sup>a</sup> = 105; 26.7% <sup>b</sup> )		
Pulmonary embolism	5	(1.3%)
Pulmonary hypertension	10	(2.5%)
Other chronic pulmonary diseases	62	(15.8%)
Other pulmonary diseases	33	(8.4%)
Other medical conditions ( <i>n</i> <sup>a</sup> = 130; 33.1% <sup>b</sup> )		
Diabetes	55	(14.0%)
Chronic renal failure	46	(11.7%)
Oncologic conditions	60	(15.3%)

<sup>a</sup>Total number of patients with preexisting conditions of this category

<sup>b</sup>Proportion of 393 patients with preexisting conditions

Preexisting conditions	<i>n</i> <sup>a</sup>	(%) <sup>b</sup>
Neurological or psychiatric conditions ( <i>n</i> <sup>a</sup> = 93; 23.7% <sup>b</sup> )		
Cerebral hemorrhage	1	(0.3%)
Seizure	1	(0.3%)
Other neurological or psychiatric conditions	92	(23.4%)
Resuscitation	10	(2.5%)
Other conditions	193	(52.9%)
<sup>a</sup> Total number of patients with preexisting conditions of this category		
<sup>b</sup> Proportion of 393 patients with preexisting conditions		

## Reasons for resuscitation

The most frequent reason of cardiac-caused resuscitation was acute coronary syndrome with 138 cases (26.1%; 95% CI, 22.4–30.1%), including 124 cases of myocardial infarction. The causes were cardiac arrhythmia, cardiogenic shock, cardiomyopathy, and cardiac decompensation in 53 (10.0%; 95% CI, 7.6–13.0%), 30 (5.7%; 95% CI, 3.9–8.1%), 13 (2.5%; 95% CI, 1.4–4.3%), and 10 (1.9%; 95% CI, 1.0–3.6%) cases, respectively. The remaining cases were summarized as other cardiac causes (Fig. 3).

## Lay resuscitation

Lay resuscitation was performed in 180 of 528 cases (34.1%; 95% CI, 30.1–38.3%). Moreover, the OHCA occurred in the presence of EMS in 55 patients (10.4%; 95% CI, 7.9–13.3%). Three (0.6%; 95% CI, 0.1–1.8%) patients were resuscitated by the first responders. Half of all lay resuscitations (94 of 180, 52.2%; 95% CI, 44.7–59.7%) were performed in patients who were already known to the CAC. Furthermore, lay resuscitation was only performed on 38.2% (94 of 246; 95% CI, 32.1%–44.6) and 34.4% (22 of 64; 95% CI, 23.0–47.3%) of previously hospitalized patients and on patients previously hospitalized because of cardiac conditions, respectively.

## Outcome

Resuscitation of 528 cardiac-caused OHCA resulted in 293 patients (55.5%; 95% CI, 51.1–59.8%) being transferred to the hospital (259 to the university CAC). Of the 259 patients admitted to the CAC, 94 (36.3%; 95% CI, 30.4–42.5%) expired during their hospital stay, and 165 patients (63.7%; 95% CI, 57.5–69.6%) survived for 30 days. Moreover, 98 (33.4%; 95% CI, 28.1–39.2%) patients admitted to a hospital were discharged from the hospital after a median of 20 [11 – 35] days. Data on neurological outcome was available for 89 of 98 (90.8%) patients. Furthermore, the CPC score at discharge was in the median of 1 [1 – 1].

Whether patients were discharged or not were undocumented in four cases.

## Outcome and lay resuscitation

Patients who received lay resuscitation were more often admitted to the hospital than were those without lay resuscitation (105 of 180 [58.3%] vs. 141 of 284 [49.6%];  $p < 0.08$ ). The overall average discharge rate for OHCA with lay resuscitation was significantly higher (47 of 180 patients, 26.1%) than for that without lay resuscitation (41 of 284 patients, 14.4%;  $p < 0.03$ ). Discharge rate was significantly higher in patients with lay resuscitation (14 of 24, 58.3%) compared to patients without lay resuscitation (8 of 34, 23.5%;  $p < 0.02$ ) in the 50- to 59-year-old age group. This was not the case for the 60- to 69-year-old (9 of 34 [26.5%] vs. 6 of 43 [14%];  $p < 0.3$ ) and 70- to 79-year-old (5 of 47 [10.9%] vs. 13 of 93 [14%];  $p < 0.8$ ) groups.

Four of nine patients (44.4%) could be discharged when the cardiac arrest occurred in the presence of an EMS/emergency physician in the 50- to 59-year-old age group. In the 60- to 69-year-old and 70- to 79-year-old age groups, zero of 10 (0.0%) and five of 17 (29.4%) patients were discharged, respectively.

A difference in cognitive outcome in patients with or without lay resuscitation was not found in this study. Cognitive outcome was very good or good (CPC 1 or 2) in the majority of patients with lay resuscitation (39 of 43 patients, 90.7%) compared to without lay resuscitation (30 of 37 patients, 81.1%;  $p < 0.32$ ).

## Discussion

This retrospective analysis of 528 OHCA cases between 2012 and 2016 from the EMS of Aachen, Germany, found that (1) almost half of these patients had been admitted to the respective CAC before OHCA; (2) three-quarters of the OHCA patients already had preexisting conditions, most commonly cardiopulmonary diseases; (3) the rate of lay resuscitation was only one-third of all OHCA patients, but patients receiving lay resuscitation were more often admitted to the hospital and were more often discharged from the hospital; and (4) only one-third of the previously hospitalized patients received lay resuscitation.

This study has several strengths. As a participant and provider of data to the German Resuscitation Registry, the current study has good data quality of all OHCA cases within the purview of the City of Aachen EMS. With only one (university) CAC in the vicinity, a high follow-up of successful OHCA resuscitations exists. However, data quality is limited by the accuracy or haziness of the documentation by the attending physicians, which is usually poorer compared to the structured prospective data collections, because this study only conducted a retrospective chart review. Both sample size and generalizability results are limited because this is the analysis of a single EMS and a single CAC.

Half of the OHCA patients had prior admission to the CAC due mostly to cardiac diagnoses. Although not surprising, no study exists that has yet quantified this proportion of prior hospitalizations and admission diagnoses. Moreover, the most common preexisting conditions were coronary artery disease and

myocardial infarction. These results are similar to other studies (e.g., an analysis of 40,000 patients from a 20-year registry found that patients with OHCA were more likely to have diabetes mellitus and myocardial infarction) (21). In addition, a systematic review analyzing the relationship between comorbidity and OHCA found that that prearrest comorbidities are associated with reduced survival and poorer neurological outcomes (22). Although the systematic review is limited by the high heterogeneity of the included studies, diabetes mellitus and myocardial infarction were especially demonstrated to be associated with poorer outcomes in OHCA patients. Nearly all of the patients with OHCA treated by the City of Aachen EMS are subsequently hospitalized in the local CAC. Available data may be incomplete if patients were treated in other hospitals or doctor's offices. Thus, patients with preexisting conditions may not have been known at the UKA and are mistakenly listed as *without prior hospitalization* and *without preexisting conditions* in this study. This could have led to an underestimation of the number of patients with prior hospitalizations and preexisting conditions.

In the current sample, a good neurological outcome, defined as CPC 1 or 2, was 9.1% higher with than without lay resuscitation. Referring to the latency time, the discharge rate decreases in inverse proportion to the latency time in the current study except for those cases that were latency free. These results are consistent with another study from 1997. This study showed that the survival probability decreases by 10% on average per minute until the start of resuscitation measures in the context of resuscitation (23).

A striking feature of the current study was the low discharge rate in patients who collapsed in the presence of the EMS/emergency personnel (EP). The potential reasons for this are symptoms existing over a longer period and resulting in greater damage, which is why the EMS/EP were alerted already before the collapse occurred in these cases. Furthermore, the comparability between the EMS/EP-witnessed resuscitations and the other cases must be questioned. Cardiac arrest observed by EMS/EP occurred in only 55 of 522 cases (10.5%) wherein the resuscitation was initially started. In addition, all patients who did not receive lay resuscitation and were discharged were nevertheless resuscitated by the EMS/EP.

The average discharge rate in the current study could have been theoretically increased by 39 patients (7.5%) to an overall discharge rate of 137 patients (from 18.6–26.1%) if lay resuscitation would have been performed in 100% of the cases and similar success rate as in the current group with lay resuscitation would have occurred. Although the rate of lay resuscitation is increasing, the discharge rate was not. Thus, lay resuscitation seems not to be sufficient. Therefore, identifying high-risk patients is especially important. Moreover, these patients, as well as their relatives, must obtain better training in resuscitation measures and recognition of emergencies to effectively increase the rate of lay resuscitation.

Further studies are needed referring the cause of cardiac-caused OHCA and better detection of high-risk patients as well as further campaigns for better education for CPR especially for these patients and their relatives.

Lay resuscitation was rather low with one-third in patients with OHCA and OHCA with prior hospitalization. This is within the European and internationally reported proportion of lay resuscitation in OHCA. Whent et al. found that lay resuscitation was much more frequent if the collapse had been observed (25.2% vs. 8.0%) and that ROSC was significantly more frequent with lay resuscitation than without (50% vs. 41.5%) (24). A significant increase in lay resuscitation was noted in Germany from 2008 to 2013 (23.4–36.9%) (25). OHCA patients in the current sample who were resuscitated by lays were more often admitted to the hospital and survived more often. The higher survival rate has also been shown by previous multiple studies (26, 27).

The low rate of lay resuscitation may offer a possibility to improve the outcomes of patients with OHCA. Effective lay resuscitation has been shown to significantly improve the likelihood of survival (28). As previously described, the frequency of lay resuscitation tremendously differs between countries. This is most likely because bystanders often have to overcome barriers as fear of harming the patient or the feeling of being at risk (29). However, the more bystanders are present, the higher the probability of a lay resuscitation (30). Moreover, lay resuscitations are significantly more frequent in public (24, 31, 32). This is despite the generally strong discrepancy existing between the general willingness of the population to perform lay resuscitation and the actual measures taken (24). Malsy et al. showed in a study with 303 subjects aged between 9 and 89 years that although almost everyone considered helping in an emergency, about 50% never participated in resuscitation training and more than 46% had their last training more than 20 years ago and never had a refresher (18). Therefore, measures such as annual CPR education of schoolchildren should be conducted because it improves performance effectiveness as well as self-efficacy (33).

Against the background of the current findings that most OHCA patients have prior been hospitalized for cardiopulmonary diagnoses or had cardiopulmonary comorbidities, this may offer a unique possibility to increase lay resuscitation rate and, therefore, patient survival. Moreover, the need for improving the lay resuscitation rate in the general public, focusing on CPR training and educating the spouses and family members of patients with cardiopulmonary hospitalizations and comorbidities, is imperative. Future research should develop scores for early OHCA risk detection and measure the effectiveness of family education and training.

## Conclusions

This retrospective analysis demonstrates that half of the patients with OHCA have prior been hospitalized because of cardiopulmonary diagnoses. Furthermore, three-quarters of OHCA patients suffered from comorbidities, especially cardiopulmonary diseases. However, the lay resuscitation rate was as low as only one-third in all patients and risk patients, i.e., previously hospitalized or suffering from relevant comorbidities. Offering education and training to spouses and family members of risk patients may increase the lay resuscitation rate and ultimately the outcome of OHCA patients.

## List Of Abbreviations

AA Arabi AR

CA Cardiac arrest

CAC Cardiac arrest center

CARES Cardiac Arrest Registry to Enhance Survival

CPC Cerebral performance category

EMS Emergency Medical Service

EP Emergency personnel

OHCA Out-of-hospital cardiac arrest

ROSC Return of spontaneous circulation

## **Declarations**

### **Ethics approval and consent to participate**

University Hospital RWTH Aachen, Reg.-Nr. EK 109/15

### **Consent for publication**

Not applicable

### **Availability of data and materials**

The datasets used and/or analysed during the current study are available from the archive of the emergency physician protocols of the professional fire brigade Aachen

### **Competing interests**

All authors have no conflicts of interest.

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### **Authors' contributions**

H. K. Heymes: Conceptualization, Methodology, Validation, Formal analysis, Writing - Original Draft, Writing - Review & Editing, Visualization

H. Schröder: Conceptualization, Resources, Writing - Review & Editing

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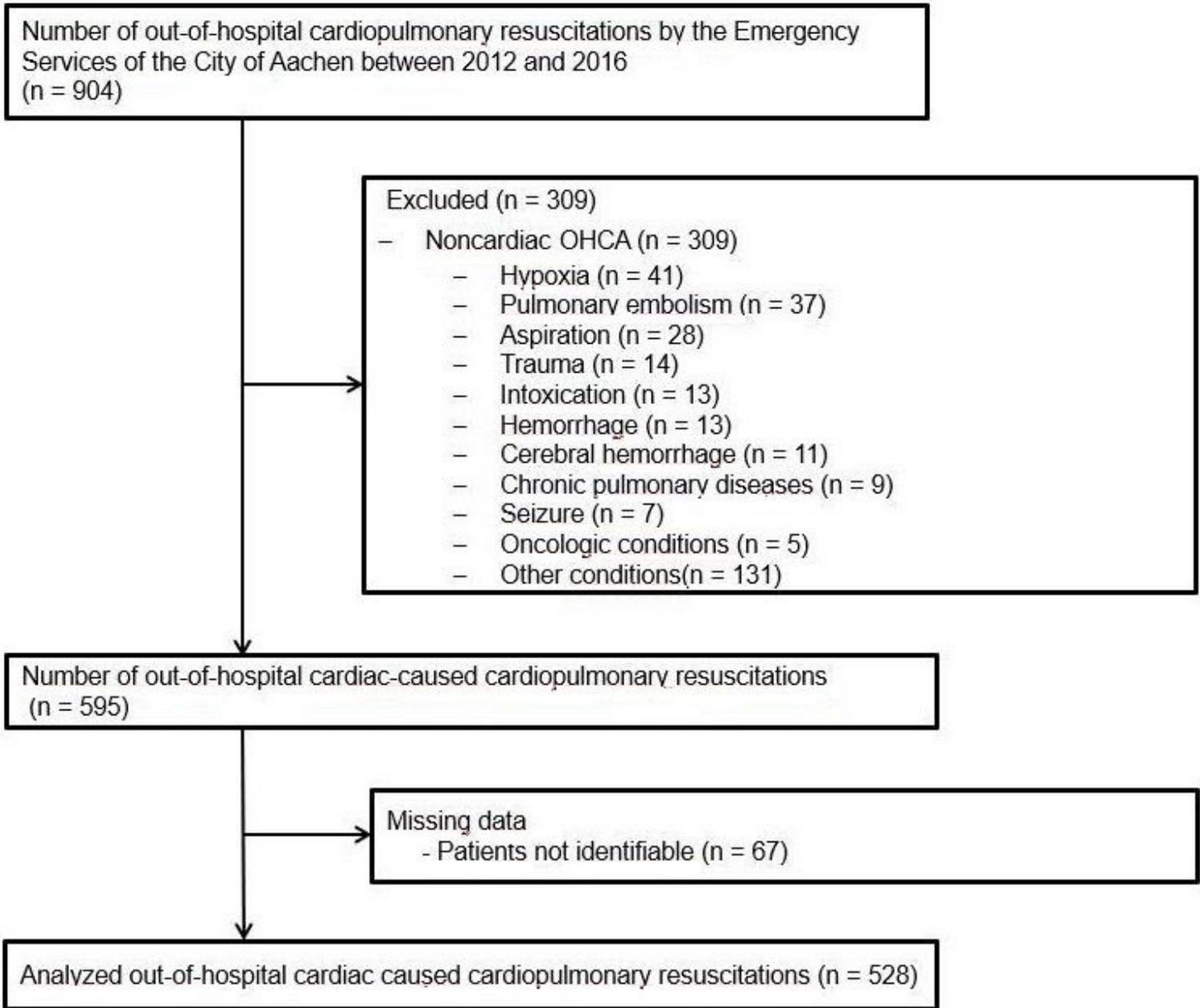
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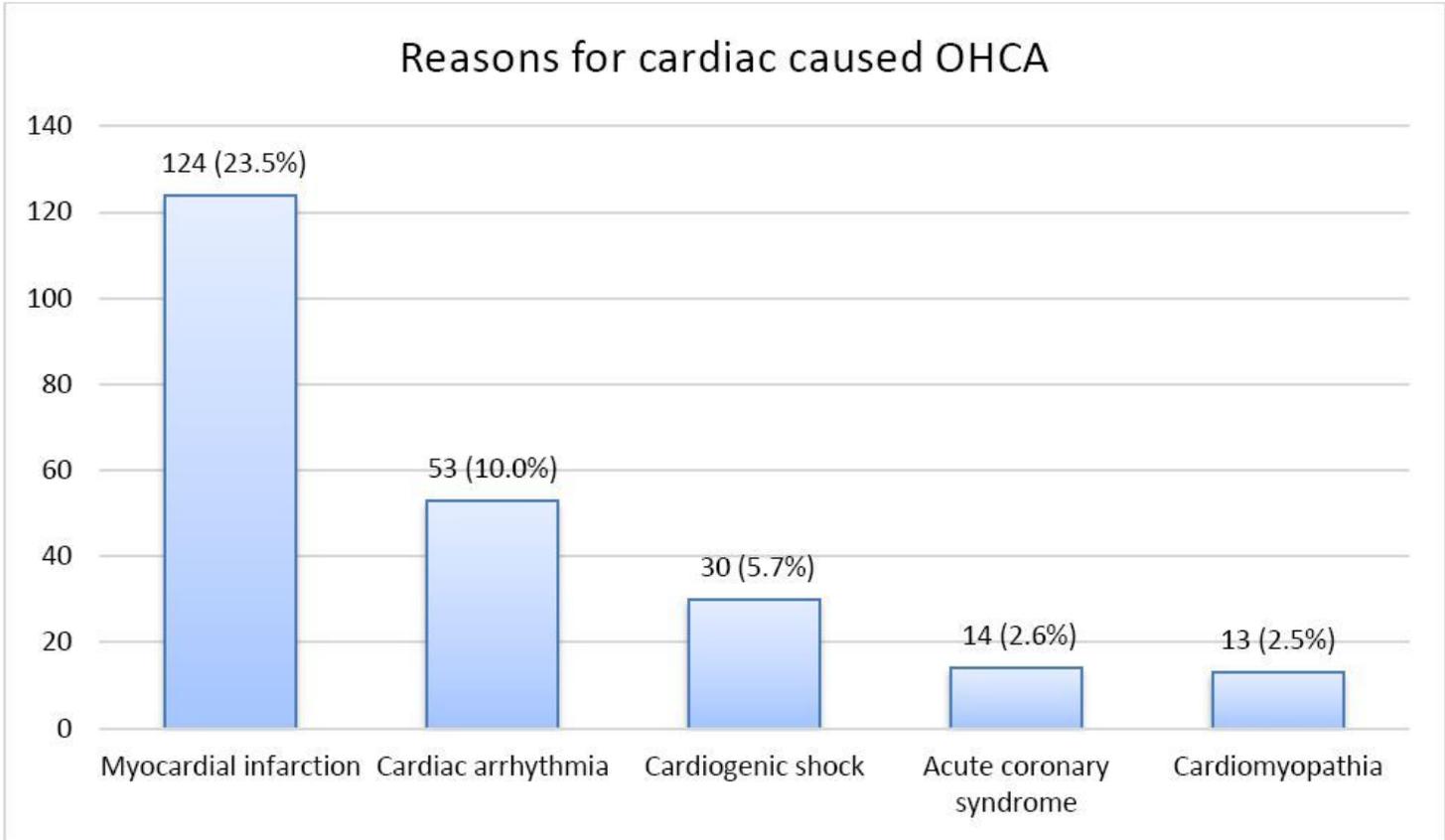
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## Figures



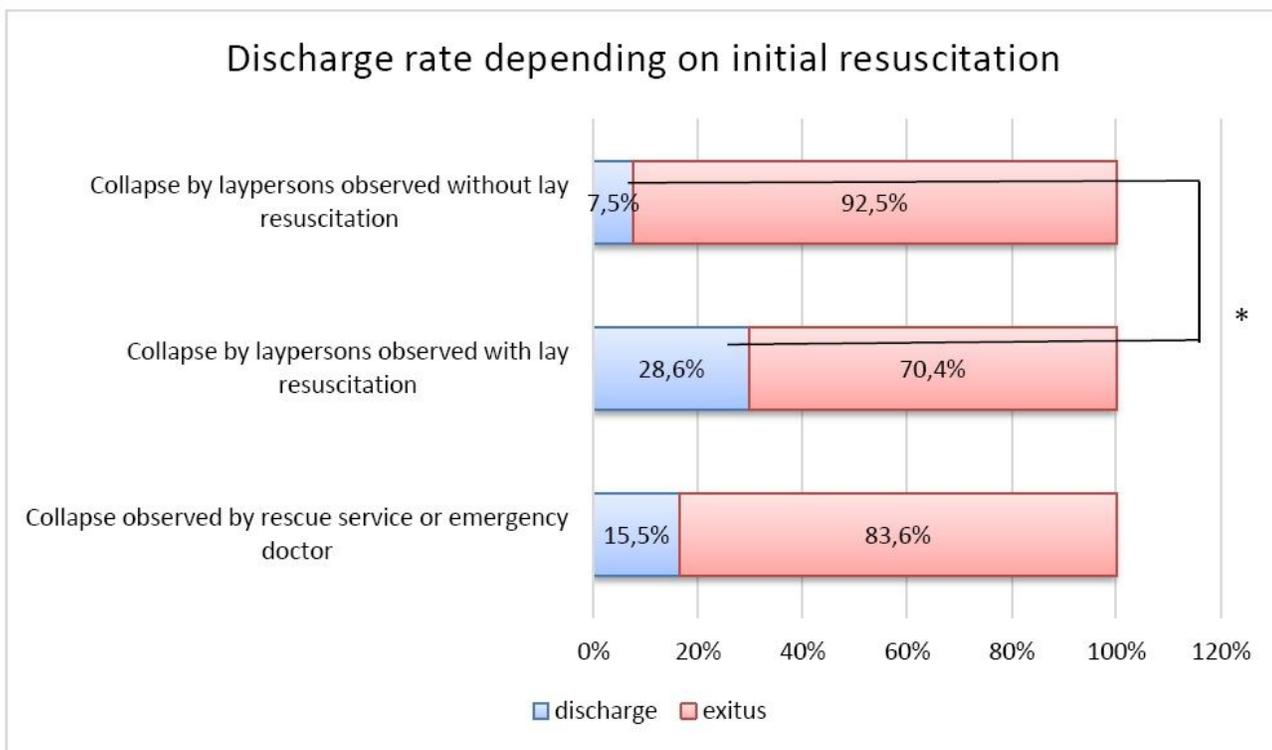
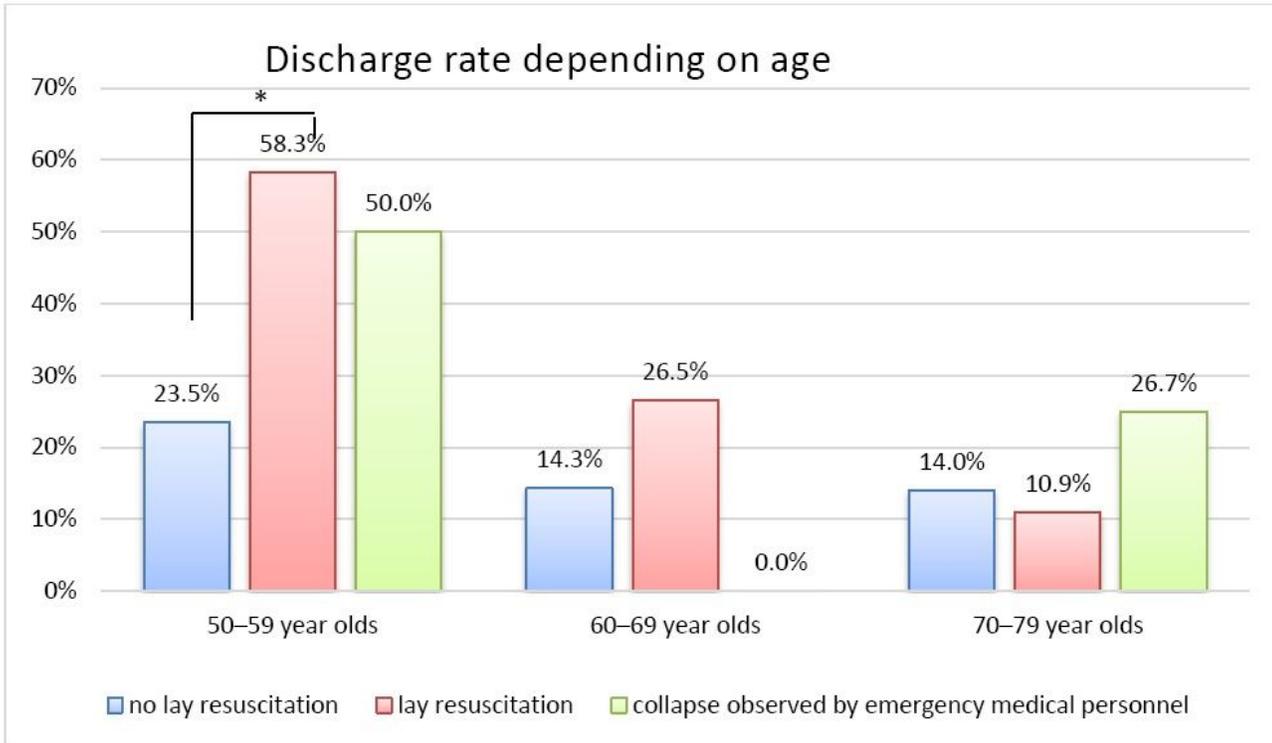
**Figure 1**

Flowchart showing the composition of the study cohort.



**Figure 2**

Most frequent reasons for cardiac-caused OHCA



**Figure 3**

Discharge rate depending on age and initial resuscitation Above Discharge rate depending on patients' age. In the 50- to 59-year-old age group, the discharge rate was significantly increased ( $p < 0.05$ ) by lay resuscitation compared with no lay resuscitation. The other values did not differ significantly from each other. Below Discharge rate depending on by whom initial resuscitation was performed. The discharge

rate with lay resuscitation was significantly higher than that without ( $p < 0.05$ ). The other values did not differ from each other significantly.