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RESEARCH ARTICLE

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Compliance with CPR quality guidelines and survival after 30 days following out-of-hospital cardiac arrest. A retrospective study

Valtteri Järvenpää[1,2] | Paula Mäki[2] | Heini Huhtala[3] | Heini Elo[4] | Sami Länkimäki[2] | Piritta Setälä[2] | Sanna Hoppu[2]

[1]Faculty of Medicine and Health Technology, Tampere University, Tampere, Finland

[2]Emergency Medical Services, Centre for Prehospital Emergency Care, Pirkanmaa Wellbeing Services County, Tampere, Finland

[3]Faculty of Social Sciences, Tampere University, Tampere, Finland

[4]Southern Ostrobothnia Wellbeing Services County, Seinäjoki, Finland

Correspondence
Valtteri Järvenpää, Faculty of Medicine and Health Technology, Tampere University, FI-33014 Tampere, Finland.
Email: valtteri.jarvenpaa@tuni.fi

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Abstract

Background: Our study assessed the quality of cardiopulmonary resuscitation (CPR) given by emergency medical services in Southern Ostrobothnia Finland, as is advised in the international guidelines. The goal was to evaluate the current quality of CPR given to patients who suffered an out-of-hospital cardiac arrest and to examine possible measures for improving emergency medical services.

Methods: A retrospective study was conducted on out-of-hospital cardiac arrest patients in Southern Ostrobothnia, Finland, during a three-year period. Confounding caused by each patient's individual medical history was addressed by calculating Charlson Comorbidity Index (CCI), a score describing individual's risk for death in 10 years. The Utstein analysis and the CPR metrics were acquired from the medical records hospital district in question and analysed in an orderly manner using SPSS. Descriptive statistics are presented as mean (SD) and median [IQR].

Results: We found that of the 349 patients, 144 (41%) received ROSC, 96 (28%) survived to the hospital and 51 (15%) survived for at least 30 days. CPR metrics data were available for 181 patients. CCIs were 3.0 versus 5.0 ($p = .157$) for the ones who did and those who did not survive at least 30 days. Correspondingly, following metrics were as follows: Mean compression depth was 5.1 (1.3) versus 5.6 (0.8) cm ($p = .088$), median 28 [18;40] versus 40 [26;54]% of the compressions were in target depth ($p = .015$) and median compression rate was 113 [109;119] versus 112 [108;120] min^{-1} ($p = .757$). The median no-flow fraction was 5.1 [2.8;7.1] versus 3.7 [2.5;5.5] s ($p = .073$). Ventricular fibrillation (OR 8.74, 95% CI 2.89–26.43, $p < .001$), public location (OR 3.163, 95% CI 1.03–9.69, $p = .044$) and compression rate of 100–110/min (OR 7.923, 95% CI 2.11–29.82, $p = .002$) were related to survival.

Conclusion: Patients who suffered out-of-hospital cardiac arrest in Southern Ostrobothnia received CPR that met the international CPR quality target values. The proportion of unintentional pauses during CPR was low and the 30-day survival rate exceeded the international average.

KEYWORDS
cardiopulmonary resuscitation, cardiopulmonary resuscitation quality, emergency medical services, out-of-hospital cardiac arrest

Editorial Comment

This study assessed the quality of delivered cardiopulmonary resuscitation for cardiac arrest cases outside the hospital in a region of Finland. Review of the case records showed that CPR quality as delivered was good, with few deviations from treatment guidelines and with associated good mortality results.

1 | INTRODUCTION

International guidelines advise high-quality cardiopulmonary resuscitation (CPR) to ensure the best possible outcome for cardiac arrest (CA) patients and to enable improvement of the team and the department providing CPR.[1] The chain-of-survival describes the sequence of events vital for surviving, such as early recognition of a cardiac arrest, high-quality chest compressions, early defibrillation and post-resuscitation care.[2] According to the uniform reporting of measured CPR quality guidelines and previous publications, specific CPR metrics to follow and report are episode duration, chest compression depth, chest compression rate, no-flow time, chest compression fraction (CCF) and chest compression release velocity (CCRV).[3–6] These variables have evidence-based referral values that are associated with better prognosis.[2,5–9] Correspondingly, deviation from these referral values is associated with worse prognosis.[2,5–9] CCRV affects the diastolic function of the heart and higher CCRV is associated with improved outcomes.[10] The chest compression fraction ≥60% is associated with improved outcomes.[11] Long pauses and too shallow compressions during CPR worsen the outcome drastically.[12–14]

This study was conducted to evaluate the quality of CPR metrics of out-of-hospital cardiac arrest (OHCA) patients in the hospital district of Southern Ostrobothnia Finland and to assess how the CPR metrics reflecting the quality of chest compression affect 30-day survival when each patient's individual medical history and age were taken account as confounding factors.

2 | METHODS

2.1 | Study design

Our study was a retrospective cohort study. The data used in our study were prospectively collected as a part of standardised care.

2.2 | Study population and patient inclusion

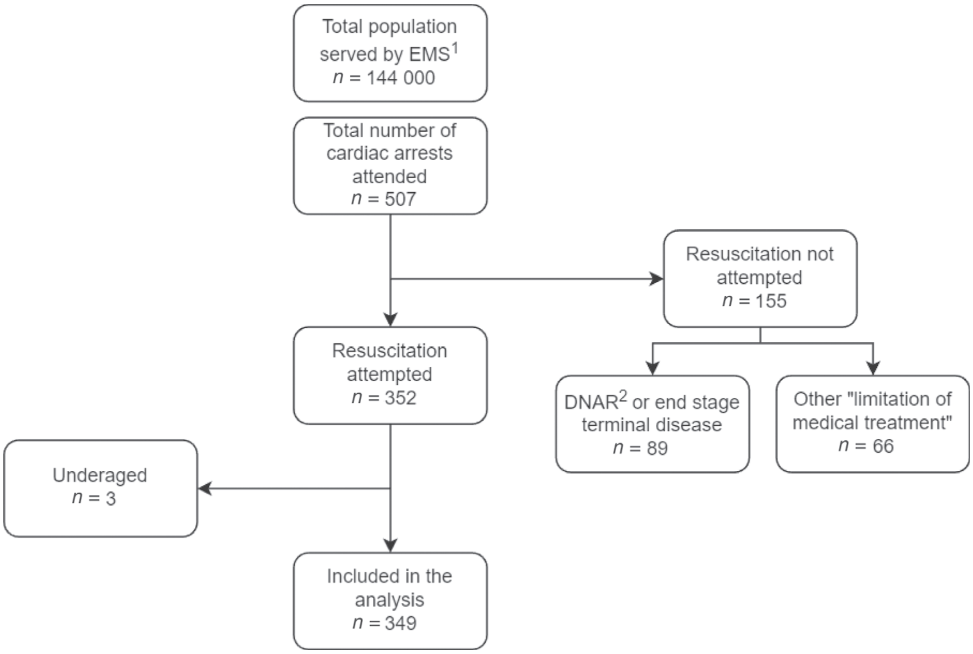
The population in Southern Ostrobothnia is 193,000 and emergency medical services (EMS) attend 48,000 cases yearly.[15] There are 16 advanced life support (ALS) and four basic life support (BLS) EMS units operating in the area.[16] BLS units can provide basic life-saving medications and first aid procedures. ALS units can provide more advanced treatments, including extracorporeal pacing and transportation while monitoring and maintaining the vital functions of an unstable patient. Southern Ostrobothnia is a sparsely inhabited area, as the population density is only 13.9/km^2.[15]

EMS in Finland provides professional acute healthcare for those who have become critically ill or injured. National emergency response centres respond to emergency calls and dispatch units according to a systematic urgency classification (A–D). While sending an EMS unit to the scene, they also assist the caller over the phone, if necessary. As the EMS unit arrives on the scene, the paramedics re-evaluate the level of urgency. Based on the evaluation at the scene, the patient is provided with acute care and treatment and then transferred to the appropriate health care facility via ambulance or helicopter.[17]

Post-resuscitation care is started immediately after a sustained ROSC. It means proper airway management and taking care of oxygenation (SpO2 > 96%), ventilation (EtCO2 4-5,5 kPA) and also adequate level of blood pressure (MAP >65 mmHg). In the hospital, if there is any evidence of myocardial ischaemia, coronary angiography is done. This is followed by CT brain and/or CT pulmonary angiography if coronary angiography fails to identify the cause of cardiac arrest. Almost every patient survived to the hospital is admitted to the intensive care where temperature management is the golden standard.

The data we collected consists of OHCA patients treated by EMS in Southern Ostrobothnia, Finland, from May 2018 to April 2021. In the spring of 2018, the hospital district of interest began to use the new generation defibrillators from ZOLL and additionally invested time educating the personnel to use this modern equipment as a part of CPR teamwork. All the OHCA's regardless of the initial rhythm or presumed aetiology, were considered eligible for the study, but cases, where CPR was incidentally given against the do-not-attempt-resuscitation (DNAR) guidelines, were excluded from the survival analysis (Figure 1). In addition, for CPR metrics analysis, we excluded all patients under 18 years of age because the guidelines are alternate for paediatric patients, and aetiologies alter compared to adult patients.[18] A minimum of one 2-min resuscitation period was required to include as a case for the analysis of the CPR metrics. Patients resuscitated using a mechanical chest compression device were excluded.

FIGURE 1 Patient inclusion for the analysis.



2.3 | Ethical issues

Our study protocol was approved by the Institutional Review Board of Tampere University Hospital on June 12, 2018 (Approval no: R18100). The study was also accepted by the director of Southern Ostrobothnia Central Hospital in August 2021. Written consent was considered unnecessary due to the observational nature of the study, and it converges with the 30th paragraph of the Declaration of Helsinki. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

2.4 | Equipment

We obtained data using ZOLL's X-series defibrillators (ZOLL X Series, Real CPR Help, ZOLL Medical Corporation, USA), which are readily used as part of standardised care in Southern Ostrobothnia. Compared to their predecessors, these defibrillators have a chest compression quality sensor attached to the CPR electrodes. This sensor enables the collection of data regarding the quality of the chest compressions.

2.5 | Data collection

In addition to CPR metrics data, we collected initial rhythm, location of the arrest, bystander CPR, use of a mechanical chest compression device and Utstein aetiology to assess their effect on the outcome of the resuscitation (return of spontaneous circulation [ROSC], survival to hospital, 30-day survival). We gathered data from the prospectively collected CPR database in the Southern Ostrobothnia Hospital District. Each resuscitation episode contained a timeline of the events concerning resuscitation.

We collected the age, sex and medical records of the patient to control for confounding factors caused by the patients' medical history. Based on those we calculated the Charlson comorbidity index (CCI) score for every case where the CPR metrics data was available. The CCI is a validated scoring system to evaluate the risk for 10-year mortality based on patients' individual medical history.[19]

We analysed CPR metrics data using dedicated quality analysis software (RescueNet Event Summary, ZOLL Medical Corporation, USA). The onset of the CPR episode pauses in CPR, ROSC and the end of an episode marked by the defibrillator were confirmed by a researcher (VJ or PM) before downloading each case. The beginning of the CPR episode analysed was defined as starting from the first compression. To tell compressions apart from errors caused by moving the patient, etc., we compared simultaneous waveform and compression depth data. ROSC was defined as ECG's QRS complexes commonly associated with blood circulation. We acknowledge that ECG does not guarantee blood circulation. However, the reporting of ROSC time stamps was, to some extent, inconsistent with the time stamps presented in the quality CPR data. Therefore, we had to use the ECG to confirm the exact timestamp retrospectively during data analysis. In addition to the QRS form, we used the capnography value, when available, to estimate whether a pause in resuscitation was due to ROSC. Researcher PM, a consultant anaesthesiologist with clinical experience in intensive care and prehospital emergency medicine, evaluated the time stamps separately.

Reporting the resuscitation data was done in accordance with a uniform model for reporting resuscitation quality, the Utstein template.[4] The most essential variables reported were episode duration, compression depth, chest compression rate, no-flow time, CCF and CCRV. Compression depth was defined as the posterior movement of the anterior chest wall when compressed. The compression rate is the number of compressions delivered to the chest per minute. Episode duration was defined as the time from the first compression to the acquisition of definitive ROSC or withdrawal from resuscitation. No-flow time was defined as the sum of pauses between two compressions that were ≥1.5 s apart and not caused by a momentary ROSC. Momentarily achieved ROSCs during the resuscitation period were excluded from the data to evaluate the no-flow fraction more accurately.

Therefore, this includes pauses caused by defibrillation but does not acknowledge possible pauses preceding EMS arrival and defibrillator installation. The CCF is defined as the fraction of time that CPR was given appropriately divided by the resuscitation episode duration. CCRV describes the maximum speed with which compression is released from the chest.[10]

2.6 | Outcome measure

We aimed to assess whether the quality of CPR metrics alters between the survivors and non-survivors. Secondarily we evaluated the adherence to international CPR quality guidelines.[20] Additionally the outcomes of the resuscitations in comparison to international counterparts were of interest.

A good CPR was defined as a target depth of 50–60 mm compressions, a proportion of compressions in target depth ≥60%, and a compression rate of 100–120 min^{-1}. A no-flow fraction below 10% was considered appropriate. The CCRV approach was similar to that of Vadeboncoeur et al., as we divided this variable into three categories: ≥400 mm/s, 300–399.9 mm/s and <300 mm/s.[21,22]

Clinical outcome was reported as a survival status 30 days after the suffered OHCA and additionally Cerebral Performance Categories (CPC) were reported. CPC is commonly used to measure neurological outcome and is also advised by the international guidelines.[23]

2.7 | Statistical analysis

The CCI score along with the CPR data from the defibrillator database (ZOLL) and formal Utstein information about the OHCAs were collected and linked together. Numbers were presented as mean (SD) or median [IQR], depending on the distribution of the analysed variable. All testing was two-sided. The differences between groups were analysed using a chi-square test with continuity correction for categorical data and a t-test or a Mann–Whitney test for continuous data, as appropriate. The demographic information of the data was acquired by using descriptive statistics in IBM SPSS Statistics, Version 27.0. Armonk, NY: IBM Corp. Univariable and multivariate binary logistic regression analyses were also performed to assess the factors' effects on the long-term outcome. The effects of the missing CPR metrics data on the outcomes were assessed by comparing the demographics of these groups using previously mentioned tests. Patients who had the CPR metrics data available had complete data sets; therefore, we did not have to handle missing data points.

3 | RESULTS

3.1 | Patients included in the study

In total, there were 507 reported OHCAs in Southern Ostrobothnia over 3 years, from 05/18 to 04/21. In 155 cases CPR was not attempted by the EMS and thus those cases were excluded from the data. In those cases, resuscitation was not attempted due to pre-existing DNAR or other 'limitation of medical treatment' reasons. Furthermore, three additional cases were excluded for being underaged. 349 patients were initially eligible for the analysis (Figure 1). However, CPR metrics data was available for only 181 patients (Figure 2).

In comparison of the groups with and without the CPR metrics data, the groups were alike (Tables 1 and 2).

3.2 | CPR metrics data demographics

Of the 181 patients who had CPR metrics data available, 130 (72%) were male. The median episode duration was 20 [13;27] min. The mean

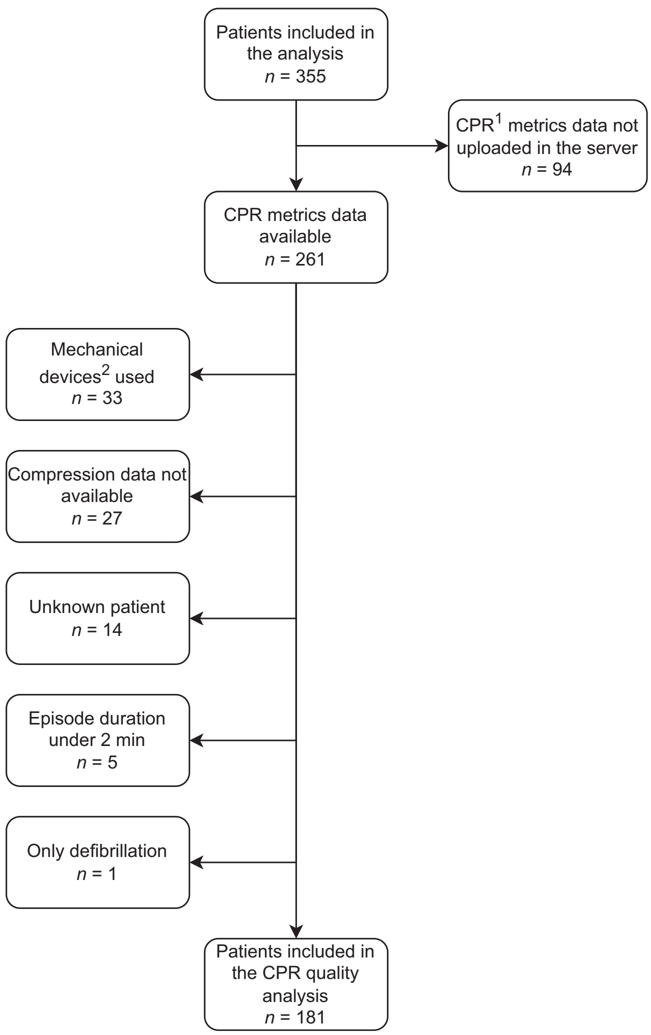


FIGURE 2 Patient inclusion for CPR quality analysis.

TABLE 1 Demographics of the patients with and without quality CPR data.

Demographics	With quality CPR[a] data		Without quality CPR data		p value
	n = 181	%	n = 168	%	
Age					
Years, median (min–max)	74	18–98	74	18–96	.934
Male median (Q1–Q3)	72	62–78	72	59–80	
Female median (Q1–Q3)	81	66–90	80	73–87	
Sex					.410
Male (n)	130	72	109	65	
Female (n)	51	28	53	32	
Data missing	0	0	6	3.6	
Location of the arrest					.94
1 (home)	116	64	105	63	
2 (work)	31	17	27	16	
3 (education)	14	7.7	11	6.5	
4 (public in)	9	5.0	14	8.3	
5 (public out)	7	3.9	8	4.8	
6 (nursing)	1	0.6	1	0.6	
7 (ambulance)	1	0.6	0	0.0	
8 (unknown)	2	1.2	2	1.2	
Witnessed					.551
1 (bystander)	119	66	98	58	
2 (found)	30	17	36	21	
3 (while EMS[b] at scene)	27	15	29	17	
4 (unknown)	5	2.0	5	3.0	
Bystander CPR					.733
1 (compressions & ventilation)	27	15	28	17	
2 (only ventilation)	1	0.7	3	1.8	
3 (only compressions)	63	35	49	29	
4 (nothing)	55	30	51	30	
5 (SCA[c] while EMS at scene)	31	17	31	19	
6 (unknown)	4	2.3	6	3.6	
AED[d] used					.605
Yes, defibrillation	3	1.7	5	3.0	
Yes, no defibrillation	7	3.9	7	4.2	
No	143	79	123	73	
Unknown	28	16	33	20	
Initial rhythm					.759
1 (VF[e])	43	24	33	20	
2 (pulseless VT[f])	2	1.2	4	2.4	
3 (ASY[g])	72	40	70	42	
4 (PEA[h])	48	26	40	24	
5 (defibrillable)	4	2.2	7	4.2	
6 (non-defibrillable)	8	4.4	8	4.8	
7 (unknown)	4	2.2	6	3.6	
Utstein aetiology					.404
1 (trauma)	6	3.4	11	6.5	
2 (overdose)	4	2.3	2	1.2	

(Continues)

TABLE 1 (Continued)

Demographics	With quality CPR[a] data n = 181	%	Without quality CPR data n = 168	%	p value
3 (drowning)	0	0.0	1	0.6	
4 (electrocution)	0	0.0	0	0.0	
5 (suffocation)	2	1.3	3	1.8	
6 (medical)	169	93	150	89	
7 (unknown)	0	0.0	1	0.6	
Median call to ROSC[i] (minutes)	28	18–42	32	19–46	.407
Median call to exitus[j] (minutes)	37	28–48	35	27–45	.343

[a]Cardiopulmonary resuscitation;
[b]Emergency medical services;
[c]Sudden cardiac arrest;
[d]Automated external defibrillator;
[e]Ventricular fibrillation;
[f]Ventricular tachycardia;
[g]Asystole;
[h]Pulseless electric activity;
[i]Return of spontaneous circulation;
[j]inc. only patients who did not receive ROSC.

TABLE 2 Outcomes of the patients with and without quality CPR data.

Demographics	With quality CPR[a] data n = 181	%	Without quality CPR data n = 168	%	p value
Final outcome					.926
Deceased at scene	104	57	101	60	
ROSC[b]	77	43	67	40	
Survived to hospital	51	28	45	27	
30-day survival	26	14	25	15	
CPC[c] score[d]					.131
1	15	58	21	84	
2	5	19	3	12	
3	2	7.7	1	4	
4	0	0	0	0	
5	4	15	0	0	

[a]Cardiopulmonary resuscitation;
[b]Return of spontaneous circulation;
[c]Cerebral performance categories, sudden cardiac arrest;
[d]Percentage calculated from 30-day survivors.

compression depth was 5.5 (0.9) cm, and during the CPR episode, a mean of 38 (20) % of the compressions were within the target depth. The median compression rate was 112 min^{-1} [108;120]. Median 70 [48;83] % of minutes, the compression rate was between 100 and 120 min^{-1}. The median compressions delivered per minute were 100 [92;106]. The median no-flow time was 44 [25;77] s, while the median no-flow fraction was 3.9% [2.7;6.1]. The mean CCRV was 364 (65) mm/s.

3.3 | The outcome

We found that of the 349 patients, 144 (41%) received ROSC, 96 (28%) survived to the hospital and 51 (15%) survived for at least 30 days. Of those patients who had the CPR metrics data ($n = 181$) available, 77 (43%) received ROSC, 51 (28%) survived to the hospital and 26 (14%) survived for at least 30 days.

There were certain differences between the survivors and non-survivors within the group of 181 patients who had the CPR metrics data available. The response time from the beginning of the call to EMS being at the scene for survivors was median of 7 min 54 s [5 min 3 s;11 min 50 s] as opposed to 10 min 0 sec [7 min 0 s; 16 min 0 s] for non-survivors ($p = .030$). The location of the arrest ($p = .018$) and the initial rhythm ($p = .003$) differed between survivors and non-survivors (Table 3).

There was a difference in survival between sexes ($p = .012$), as 18% of males survived, compared to 4% of females. The age-corrected odds for 30-day survival also favoured males (OR 4.97; CI 1.10–22.5;

TABLE 3 Demographics of the patients with CPR metrics data.

Demographics (CPR[a] metrics)	30-day survival				
	Yes		No		
	$n = 26$	%	$n = 155$	%	p value
Age					
Median (min–max)	68	38–90	75	18–98	.061
Male median (Q1–Q3)	70	57–76	72	62–79	.523
Female median (Q1–Q3)	65	64–65	82	72–90	.099
Sex					.012
Male (n)	24	92	106	68	
Female (n)	2	8.0	49	32	
CCI,[b] median (Q1–Q3)	3.0	2.0–6.3	5.0	3.0–6.0	.157
Location of the arrest					.018
1 (home)	14	54	102	66	
2 (work)	8	31	23	15	
3 (education)	0	0	14	9.0	
4 (public in)	0	0	9	5.7	
5 (public out)	3	12	4	2.5	
6 (nursing)	0	0	1	0.6	
7 (ambulance)	1	3.0	0	0	
8 (unknown)	0	0	2	1.2	
Witnessed					.789
1 (bystander)	18	69	101	65	
2 (found)	3	12	27	17	
3 (while EMS[c] at scene)	5	19	22	14	
4 (unknown)	0	0	5	4.0	
Bystander CPR					.109
1 (comps and vents)	2	7.9	25	16	
2 (only vents)	0	0	1	0.4	
3 (only comps)	11	42	52	34	
4 (nothing)	5	19	50	32	
5 (SCA[d] while EMS at scene)	7	27	24	16	
6 (unknown)	1	4.0	3	1.6	
AED[e] used					.002
Yes, defibrillation	3	12	0	0	
Yes, no defibrillation	0	0	7	4.5	
No	21	81	122	79	
Unknown	2	7.7	26	17	
Initial rhythm					.003
1 (VF[f])	15	58	28	18	
2 (pulseless VT[g])	0	0	2	1.2	
3 (ASY[h])	4	15	68	44	
4 (PEA[i])	5	19	43	28	
5 (defibrillable)	0	0	4	2.5	
6 (non-defibrillable)	2	8.0	6	3.8	
7 (unknown)	0	0	4	2.5	
Utstein aetiology					.401
1 (trauma)	2	8.0	4	2.4	

(Continues)

TABLE 3 (Continued)

	30-day survival				
	Yes		No		
Demographics (CPR[a] metrics)	$n = 26$	%	$n = 155$	%	p value
2 (overdose)	0	0	4	2.4	
3 (drowning)	0	0	0	0	
4 (electrocution)	0	0	0	0	
5 (suffocation)	0	0	2	1.2	
6 (medical)	24	92	145	94	
7 (unknown)	0	0	0	0	

[a]Cardiopulmonary resuscitation;
[b]Charlson comorbidity index;
[c]Emergency medical services;
[d]Sudden cardiac arrest;
[e]Automated external defibrillator;
[f]Ventricular fibrillation;
[g]Ventricular tachycardia;
[h]Asystole;
[i]Pulseless electric activity.

$p = .037$). Furthermore, the initial rhythms were similar ($p = .075$) for both sexes.

The CPR metrics are presented in Table 4. The episode duration for survivors was shorter compared to non-survivors (13 vs. 20 min, $p = .044$). The percentage of compressions below 50 mm of depth (32% vs. 21%, $p = .013$) and compressions delivered/min (90 vs. 99, $p = .008$) were worse amongst the group of survivors. Mean compression depths for both survivors 51 mm (13, CI 95% 46–56) and non-survivors 56 mm (8, CI 95% 55–57) were in the target range ($p = .088$).

Factors predicting 30-day survival were added to the regression analysis (Table 5). There was no statistically significant difference in CCI between patients who did and did not survive for at least 30 days (3.0 vs. 5.0, $p = .157$) (Table 3). Ventricular fibrillation (OR 8.74, 95% CI 2.89–26.43, $p < .001$), public location (OR 3.163, 95% CI 1.03–9.69, $p = .044$) and compression rate of 100–110/min (OR 7.923, 95% CI 2.11–29.82, $p = .002$) were associated with 30-day survival.

4 | DISCUSSION

4.1 | Key findings

The 30-day survival rate for the whole population was 15%, which was good, and the CPR metrics reflecting the quality of the chest compressions given by the EMS mainly met the CPR guideline target values. Sex, initial rhythm and event location were important regarding survival. Furthermore, a shorter resuscitation period was associated with improved chances of 30-day survival.

4.2 | Relationship to previous studies

Although the CPR provided by the EMS staff mainly met the predefined quality criteria, some of these variables related to CPR metrics were worse for those who survived at least 30 days. The episode duration was shorter amongst the ones that survived at least 30 days and those patients also had a higher percentage of compressions below 50 mm in depth. In addition, the depth of CPR was found to be within the recommended range of the guidelines for both groups, making it more difficult to draw conclusions. The fact that non-survivors had confidence intervals at the recommended limits makes the interpretation of the results more complicated. Despite minor alterations in CPR quality, the whole Southern Ostrobothnia hospital district reached similar ROSC (41% vs. 44%) and hospital admission (28% vs. 35%) rates as in FINNRESUSCI study carried out in 2012.[24] It is worthy to mention that our study population included 1 central hospital and 1 urban municipality compared to FINNRESUSCI's 2 university hospitals, 7 central hospitals and approximately 20 urban municipalities.[25–27]

These findings may be best explained by the recognised phenomenon where shorter periods of CPR present a poorer quality due to the busy nature of the beginning of the resuscitation episode.[9] As the resuscitation event continues, quality tends to improve a there are less things to concentrate on. Regardless of these findings, the 30-day survival rate of 15% (and 14% for the group that had CPR metrics data available) was above the European average of 8–11.7%.[28,29] That leads to a question whether after certain level of quality in CPR metrics has been reached, should one seek for improvements from the other parts of the chain-of-survival. Additionally, the possible very low circulatory activity caused by certain initial rhythms, such as ventricular tachycardia (VT) and pulseless electric activity (PEA), might

TABLE 4 Binary logistic regression analysis of the factors predicting 30-day survival of the CPR patients with the quality CPR data.

	30-day survival							
	Yes		No			Univariate analysis		
Demographics (CPR[a] metrics)	n = 26	*	n = 155	*	p value	Odds ratio	95% CI	p value
Age						0.98	0.95–1.01	.106
Median (min-max)	68	38–90	75	18–98	.061			
Male median (Q1–Q3)	70	57–76	72	62–79	.523			
Female median (Q1–Q3)	65	64–65	82	72–90	.99			
Sex					.012			
Male (%)	24	92	106	68		3.62	1.04–12.66	.043
Female (%)	2	8	49	32		1		
From call to ROSC[b] (minutes), median (Q1–Q3)	25	15–41	28	20–42	.236	1.01	0.99–1.04	.400
From call to the scene (minutes), median (Q1–Q3)	8.0	5–12	10	7–16	.03	1.00	1.00–1.00	.058
CPR metrics								
Episode duration, median (Q1–Q3)	13	9.0–32	20	15–27	.044	0.98	0.94–1.02	.401
Compression depth mean, cm (SD)	5.1	1.3	5.6	0.8	.088	0.58	0.37–0.89	.014
Percentage of compressions below 50 mm in depth, median (Q1–Q3)	32	19–65	21	8.5–42	.013	1.02	1.00–1.03	.012
compressions in target depth %, median (Q1–Q3)	28	18–40	40	26–54	.015	0.97	0.95–0.99	.013
Compression rate/min, median (Q1–Q3)	113	109–119	112	108–120	.757	0.98	0.94–1.02	.272
Fraction of compression with rate/min <100 or >120, median (Q1–Q3)	33	19–50	29	16–53	.484	1.00	0.99–1.02	.755
Compressions delivered/min, mean (SD)	90	20	99	14	.008	0.97	0.94–0.99	.010
No-flow fraction, median (Q1–Q3)	5.1	2.8–7.1	3.7	2.5–5.5	.073	1.08	1.01–1.16	.025
CCRV[c], mean (SD)					.355	1.00	0.99–1.00	.109
<300	5	19	15	10				
≤300–<400	15	58	101	65				
400≤	6	23	39	25				

[a]Cardiopulmonary resuscitation;
[b]Return of spontaneous circulation;
[c]Chest compression release velocity.
*Contents presented in parentheses.

improve the chances for survival and thus lead to the long-term survival of the patients whose CPR has been inferior compared to those who were deceased. Another possible explanation for those controversial outcomes might be that the base level of the acute care given as a standard practice to OHCA patients is of such quality that clinically significant differences cannot be found by improving several CPR metrics. In other words, improvements in other parts of the chain-of-survival such as early recognition and early defibrillation could lead to a shorter 'from collapse to ROSC' period that could be far more superior regarding the clinical outcome than minor alterations in CPR quality.

Existing comorbidities (CCI score) did not seem to affect the 30-day survival. This may be caused by the national DNR guidelines which may vary from its counterparts and thus have led to a setting where patients with higher CCI scoring have already been excluded from the study due to a prior DNR ruling. In other studies, CCI scoring indicating higher morbidity has been associated with reduced long-term survival.[30,31]

Real-time feedback defibrillators have been linked to an improvement in adherence to resuscitation guidelines.[2,32,33] This is an important goal, and therefore, the use of automated feedback defibrillators should be encouraged. The Southern Ostrobothnia Hospital district began collecting the CPR metrics data in 2018 as they acquired new generation of defibrillators and put in a significant amount of effort to educate the EMS personnel to use these devices. Now, based on our data, we can say that the no-flow fraction was particularly low, and

TABLE 5 Binary logistic regression analysis of the factors predicting 30-day survival of the CPR patients with the CPR metrics data.

Regression analysis	OR[a]	95% CI[b]	*p* value
Primary rhythm (VF[c] vs. other)	8.74	2.89–26.43	<.001
Location (work & public vs. other)	3.16	1.03–9.69	.044
Male versus female	4.54	0.88–23.45	.071
Compressions <50 mm %	0.98	0.96–1.00	.083
Compressions in target depth %	1.01	0.98–1.04	.498
Compression rate below 100/min	1	–	.022
100–110/min	7.92	2.11–29.82	.002
110–120 min^{-1}	2.74	0.42–17.77	.29
Over 120 min^{-1}[d]	–	–	.999
CCI[e]	0.99	0.82–1.20	.929

[a]Odds ratio;
[b]Confidence interval;
[c]Ventricular fibrillation;
[d]Seven patients in this category;
[e]Charlson comorbidity index.

the compression rate met the required values. On the other hand, the compression depth varied considerably. Thus, one might conclude that further education and practice are necessary to achieve a certain level of consistency in CPR quality. However, the impact of CPR metrics on OHCA patient prognosis remains uncertain. There is no consensus on whether high-quality CPR metrics, that is, adherence to the guidelines improve the chances for survival, or after which point the quality improvement will not furthermore improve the outcomes. This might reflect EMS personnel's attitudes and partially explain the deviations from the desired quality values. Furthermore, there might be other factors, such as the size of the person in CA or the disposition of the monitor and the rescuer at the scene as the scene of events might be in a small space such as bathroom. The level of noise at the scene (e.g. shopping centre) might also cause varying resuscitation quality.

When evaluating the no-flow fraction in resuscitation studies, there are different ways in which the no-flow fraction can be defined. The common definition is time without chest compressions divided by total time without spontaneous circulation.[34] We observed only the time that the EMS was resuscitating the patient; thus, the numbers will not accurately describe the no-flow fraction of the total cardiac arrest episode. Therefore, some criticism should be applied when comparing these results with their counterparts. However, our aim was to observe the performance of EMS personnel.

4.3 | Limitations of the study

There are some limitations to this study. First, the collection of the data was retrospective and thus realised in loss of data, as the CPR metrics data was available for only 51% of the cases despite the fact that the CPR database was collected prospectively. The main issue with data availability was that the data was not uploaded to a computer server after the resuscitation attempt.

Second, our study focused only on the prehospital phase in the chain-of-survival and thus unequivocally affected the interpretation of the results. Third, we were not able to gather the following variables that are recommended for inclusion in the CPR quality analysis: the amount of incomplete chest compressions, duty cycle, ventilation rate or capnography.[3,4] In addition, we did not have the specifics about the post-resuscitation intensive care available. This was due to the retrospective nature of this study, too. Especially capnography could bring interesting and valuable additional information and should be considered in future studies.

External validity is limited. The study was conducted in a Finnish secondary-level central hospital providing advanced care for a population of 193,000 people. This fact sets the framework for overall generalizability; the findings may not be applicable in EMS/countries with different size regions or clinical practices. Additionally, the size of our study population remained quite modest and thus might cause validity issues.

5 | CONCLUSIONS

Patients who suffered an OHCA in Southern Ostrobothnia received CPR that met the international CPR quality target values. The proportion of unintentional pauses during CPR was markedly low and also the 30-day survival was above the international average.

AUTHOR CONTRIBUTIONS

All authors designed the study and drafted and critically revised the manuscript. Valtteri Järvenpää and Heini Huhtala (certified statistician) ran the statistical analyses. All authors have read and approved the final manuscript.

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DATA AVAILABILITY STATEMENT

The full dataset is available upon reasonable request from the corresponding author. Previous versions of the manuscript are available upon request from Acta Anaesthesiologica Scandinavica.

ORCID

Valtteri Järvenpää https://orcid.org/0000-0003-4860-6995

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