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Clinical paper

Initial rhythm and survival in refractory out-of-hospital cardiac arrest. Post-hoc analysis of the Prague OHCA randomized trial

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Abstract

Background: The prognosis of refractory out-of-hospital cardiac arrest (OHCA) is generally poor. A recent Prague OHCA study has demonstrated that an invasive approach (including extracorporeal cardiopulmonary resuscitation, ECPR) is a feasible and effective treatment strategy in refractory OHCA. Here we present a post-hoc analysis of the role of initial rhythm on patient outcomes.

Methods: The study enrolled patients who had a witnessed OHCA of presumed cardiac cause without early recovery of spontaneous circulation. The initial rhythm was classified as either a shockable or a non-shockable rhythm. The primary outcome was a composite of 180 day-survival with Cerebral Performance in Category 1 or 2.

Results: 256 (median age 58y, 17% females) patients were enrolled. The median (IQR) duration of resuscitation was 52 (33–68) minutes. 156 (61%) and 100 (39%) of patients manifested a shockable and non-shockable rhythm, respectively. The primary outcome was achieved in 63 (40%) patients with a shockable rhythm and in 5 (5%) patients with a non-shockable rhythm ($p < 0.001$). When patients were analyzed separately based on whether the treatment was invasive (n = 124) or standard (n = 132), the difference in the primary endpoint between shockable and non-shockable initial rhythms remained significant (35/72 (49%) vs 4/52 (8%) in the invasive arm and 28/84 (33%) vs 1/48 (2%) in the standard arm; $p < 0.001$).

Conclusion: An initial shockable rhythm and treatment with an invasive approach is associated with a reasonable neurologically favorable survival for 180 days despite refractory OHCA. Non-shockable initial rhythms bear a poor prognosis in refractory OHCA even when ECPR is readily available.

Keywords: Resuscitation, Cardiac arrest, Extracorporeal circulation, Invasive approach

Introduction

Out-of-hospital cardiac arrest (OHCA) is a significant burden to society.[1] Survival at the level of a hospital discharge with neurological and functional recovery after OHCA is low.[2] It has been reported that a good clinical outcome of treated ventricular fibrillation (VF) or pulseless ventricle tachycardia arrest is far more favorable than asystole or pulseless electrical activity (PEA).[2–6] However, half of the patients with OHCA and VF which exhibited refractory arrhythmia

Abbreviations: OHCA, out-of-hospital cardiac arrest, ECPR, extracorporeal cardiopulmonary resuscitation, VF, ventricular fibrillation, PEA, pulseless electrical activity, ROSC, recovery of spontaneous circulation, CPR, cardiopulmonary resuscitation, CA, cardiac arrest, ECR, European Resuscitation Council, LUCAS, Lund University Cardiac Arrest System, S, standard, I, invasive, CPC, Cerebral Performance Category, IQR, interquartile range, ICD, impantable cardioverter-defibrilator, EMS, emergency medical service, ACLS, advanced cardiac life support, TTM, target temperature management, MODS, multiorgan dysfunction syndrome, WLST, withdrawal of life-sustaining therapy, HR, hazard ratio, CI, confidence interval

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and were unresponsive to initial standard treatment, had a poor prognosis.[3,7] In patients who didn't have a recovery of spontaneous circulation (ROSC), the chance of survival when being transported to the hospital while still undergoing cardiopulmonary resuscitation (CPR) is low, usually less than 4% when using standard measures.[8,9]

The temporary replacement of failing circulation by extracorporeal cardiopulmonary resuscitation (ECPR), has been recognized as a promising approach to refractory cardiac arrest (CA).[10–14] Recently, a Prague OHCA study has demonstrated that an invasive approach (early transport to the hospital under mechanical CPR, ECPR, and immediate invasive assessment and therapy) is a feasible and effective treatment strategy in refractory OHCA. The trial suggested the beneficial effects of the invasive approach in the results of 30-day neurological outcome and 180-day mortality/180-day survival with a favorable neurological outcome.[15]

To date, only retrospective studies analysed the role of initial rhythms in refractory OHCA and ECPR. These data suggest poor outcomes for patients with non-shockable rhythms treated with ECPR. Many OHCA centers, therefore, reserve ECPR for VF patients only. Prague OHCA study was the first randomized refractory OHCA trial which also included patients with non-shockable rhythms.

Therefore, we hereby present an analysis on the role of the initial rhythm on patient outcomes in the refractory CA population of the Prague OHCA trial. The secondary objective was to identify the impact of the initial rhythm on the clinical outcome relating to treatment strategy approach, i.e. invasive vs standard. We hypothesized that a shockable rhythm is associated with favorable 180 days survival in refractory OHCA regardless of the treatment strategy. Further, we also hypothesized, that an invasive approach followed by ECPR might have neurologically favorable survival benefits.

Methods

The current study is a post-hoc analysis of the Prague OHCA study, a randomized controlled trial comparing the invasive approach (early transport to hospital under mechanical CPR, ECPR, and immediate invasive assessment and therapy) to standard treatment in the refractory OHCA population.[15,16] The study was performed according to good clinical practice and in compliance with the Helsinki declaration. The Prague OHCA study was approved by the Ethics committee of the General University Hospital in Prague (192/11 S-IV).

Study population

A detailed protocol of the main study has been described previously in detail.[15,16] In brief, the study enrolled adults over 18 years of age, with a witnessed OHCA of a presumed cardiac etiology, who were given a minimum of 5 minutes of advanced cardiac life support without ROSC and who remained unconscious. The patients were randomized in a 1:1 ratio into two study arms: invasive (I) or standard (S). Patients who attained ROSC during initial resuscitation, regained consciousness, or had a known or obvious life-limiting comorbidity, or bleeding diathesis were excluded. The termination of resuscitation efforts followed the valid European Resuscitation Council (ERC) guidelines.[17,18]

Intervention

Patients who were randomized to the S arm were managed on site by continued advanced cardiac life support. The use of drugs, further defibrillations, or other interventions followed the available ERC guidelines.[17,18] If ROSC was achieved (defined as cardiac electrical activity with a palpable pulse), transportation to hospital was initiated and an early invasive strategy was encouraged, namely a coronary angiography.

The mechanical chest compression device LUCAS (Lund University Cardiac Arrest System; Physio-Control Inc./Jolife AB, Lund, Sweden) was originally reserved exclusively for the I arm. However, following the publication of a major trial on mechanical chest compression,[19] the attachment of a LUCAS device was left to the discretion of the emergency physician and was allowed for use at any point during CPR.

In the I arm, the patient was immediately transferred directly to the cardiac center catheterization laboratory (Cathlab) during ongoing CPR with the intention of proceeding with ECPR if ROSC was not achieved en route or on admission. The use of drugs, further defibrillations, or other interventions during transportation followed the ERC guidelines.[17,18] Post-resuscitation care was standardized in both study arms.

Initial rhythm

For the present study, the initial rhythm was defined as the first documented rhythm by the medical emergency system. For further evaluation, initial rhythm was classified as either a shockable rhythm or a non-shockable rhythm. A shockable rhythm included VF or pulseless ventricular tachycardia, the non-shockable group consisted of asystole and PEA. The team in the intensive care unit was unblinded regarding the initial heart rhythm.

Outcomes

The primary outcome was the composite of a 180 day-survival rate with a favorable neurological status, defined as no or minimal neurological impairment (Cerebral Performance Category, CPC, 1 or 2). Secondary outcomes included a 30 day-survival rate with cardiac recovery (no need for pharmacological or mechanical cardiac support for at least 24 hours) and a neurological recovery (CPC 1 or 2) at any time within the first 30 days following the CA. Survival up to 180 days, CPC distribution, and differences in favorable survival in relationship to the length of the CA as well as adverse events incidence were also determined.

Statistical analysis

The CA time and other numeric variables are expressed as medians and interquartile ranges (IQR). The 2-sided Mann-Whitney test was used to compare the CA times and laboratory values between the shockable and non-shockable initial rhythm. The categorical values were compared using the Fisher's exact test (for 2x2 table) or the chi-square test. All presented p-values are two-tailed. We used the Fisher exact test with doubled one-sided p-value. The Cox regression model was used for multivariable survival analysis. Two models were designed. First using available variables on hospital admission. Second model included known variables or completed interventions after initial in-hospital evaluation (one hour after admission). Selection of variables included in both models was based on a significance in an univariate analysis and its clinical relevance. $P < 0.05$ was considered as statistically significant. Statistical analyses were performed with MedCalc® Statistical Software version 19.7 (MedCalc Software Ltd, Ostend, Belgium; 2021) and RStudio 2022.07.2 + 576 (RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/).

Table 1 – Baseline demographical and prehospital data.

Parameter	Shockable rhythm (*N* = 156)	Non-shockable rhythm (*N* = 100)	*P*
Age (years)	56 (45–64)	60 (51–66)	0.03
Sex			
Female	15 (10%)	29 (29%)	<0.001
Male	141 (90%)	71 (71%)	
Medical history			
Hypertension	57/126 (45%)	32/65 (49%)	0.65
Coronary artery disease	26/125 (21%)	8/62 (13%)	0.23
Chronic heart failure	10/123 (8%)	6/62 (10%)	0.78
Diabetes mellitus	18/120 (15%)	18/62 (29%)	0.03
Chronic kidney disease	2/122 (2%)	3/61 (5%)	0.34
Chronic obstructive pulmonary disease	7/122 (6%)	3/62 (5%)	1.00
ICD implanted	1/134 (1%)	2/76 (3%)	0.30
Bystander CPR	154 (99%)	98 (98%)	1.00
Time from collapse to EMS arrival (min)	9 (6–11)	9 (7–12)	0.54
Time from collapse to ACLS (physician arrival) (min)	10 (8–13)	11 (6–14)	0.87
Dispatcher assisted CPR	133 (85%)	70 (70%)	0.006
Time until or of dispatcher assisted CPR began (min)	3 (2–4)	3 (1–5)	0.97
Time from collapse to randomization (min)	25 (20–30)	24 (20–32)	0.98
Number of adrenaline doses prehospitally (mg)	4 (2–6)	5 (4–7)	<0.001
Intermittent ROSC	56 (36%)	30 (30%)	0.40
Randomised to			
Standard	84 (54%)	48 (48%)	0.44
Invasive	72 (46%)	52 (52%)	

Note: Data is expressed as median (IQR) or *N* (%). ICD – implantable cardioverter-defibrillator; CPR – cardiopulmonary resuscitation; EMS – emergency medical service; ACLS – advanced cardiac life support; ROSC – recovery of spontaneous circulation.

Results

Baseline clinical data, prehospitalization phase

During the study period, 256 patients (median age 58 years, 17% females) were enrolled and analyzed. The baseline demographic and clinical data are described in Table 1. Out of the entire study cohort, 156 (61%) patients manifested VF as an initial rhythm. The rest of the patients had an initially non-shockable rhythm: PEA in 45 (18%) and asystole in 55 (21%) cases. Not a single patient exhibited pulseless VT. Patients with VF were slightly younger, predominantly male, and less prevalently had diabetes mellitus than those without a shockable rhythm. In the VF group, telephone assisted CPR was more frequently performed and a lower number of adrenaline doses were used.

Hospitalization phase, procedures, and interventions

As Table 2 describes in detail, less patients in the shockable group died prior to admission to the hospital or within the first hour after admission, and more frequently had a sustained ROSC on admission. In-hospital target temperature management was applied more frequently in patients with VF. An invasive assessment by diagnostic angiography was performed in 93% and 81% of admitted patients in the VF and non-shockable groups, respectively, with a different spectrum of invasive procedures according to the initial rhythm. Upon admission, the VF group manifested less advanced metabolic derangement, i.e. lower lactates and higher pH. Acute coronary syndromes were more frequently identified as a cause of the CA in the VF group (89 (57%) vs 38 (38%)). The second most frequent cause of CA in the VF group was chronic coronary artery disease. On the contrary, pulmonary embolism was more frequently found in non-VF patients. Patients with a shockable rhythm were less likely to manifest organ lacerations due to CPR.

Clinical outcome

Overall, 68 (27%) patients in the whole study reached the primary outcome of neurologically favorable survival at 180 days represented by 63 (40%) patients with an initially documented VF and 5 (5%) patients with an initially non-shockable rhythm ($p < 0.001$), Table 3.

Compared to patients with a non-shockable rhythm, a higher probability of secondary outcomes of cardiac and neurological recovery at 30 days occurred in VF patients. When patients in the I and S arms were analyzed separately, the difference in primary and secondary endpoints between shockable and non-shockable initial rhythms remained significant (Table 3). Of all the patients with VF, patients treated with an invasive strategy more frequently recovered neurologically at 30 days than those in the S arm (34 (47%) vs 24 (29%); $p = 0.03$). However, the difference in the proportion of surviving patients with CPC 1 or 2 after 180 days and VF between the I and S arms was not different (35 (49%) vs 28 (33%); $p = 0.08$; Fig. 1.

In the first cox regression model (including variables known at the time of hospital admission), see Table 4, model A, a shockable initial rhythm and sustained ROSC were independently associated with a lower probability of unfavorable clinical outcome (the absence of 180 day-survival with favorable neurological outcome). The second cox regression analysis, see Table 4, model B, included variables known after initial in-hospital evaluation (within the first hour of admission). Unfavorable clinical outcome was associated with CPR > 45 minutes and not having initial shockable rhythm. Other variables such as age, gender, dispatcher assisted CPR, and acute coronary syndromes were not significantly associated with the outcome.

Table 2 – Hospitalization phase, procedures, and interventions.

Parameter	Shockable rhythm (*N* = 156)	Non-shockable rhythm (*N* = 100)	*P*
Admitted to hospital	136 (87%)	74 (74%)	0.01
Time to hospital admission (min)	55 (46–64)	51 (41–63)	0.12
Time from randomization to admission (min)	30 (23–37)	28 (20–35)	0.20
Declared dead	33 (21%)	42 (42%)	<0.001
Prehospitally	20/33 (61%)	26/33 (62%)	1.00
Within 1 hour of admission	13/33 (39%)	16/33 (38%)	
Time of CPR (time to death/ROSC or ECLS) (min)	54 (33–69)	51 (39–68)	0.33
Time of CPR subgroups			
<30 min	31 (20%)	9 (9%)	0.06
≥30 and <45 min	29 (19%)	23 (23%)	
≥45 min	96 (62%)	68 (68%)	
Sustained ROSC on admission	67 (43%)	25 (25%)	0.005
TTM used	122/136 (90%)	66/74 (76%)	0.01
ECLS			
ECLS implanted	57 (37%)	35 (35%)	0.91
Time to ECLS (min)	62 (57–73)	60 (50–66)	0.09
Invasive assessment			
Coronary angiography	126/127 (99%)	55/62 (89%)	0.002
Pulmonary angiography	8/127 (6%)	19/62 (31%)	<0.001
Aortography	22/127 (17%)	19/62 (31%)	0.06
Left ventricle angiography	29/127 (23%)	18/62 (29%)	0.37
Laboratory values on admission			
pH	7.00 (6.87–7.17)	6.85 (6.75–6.97)	<0.001
Lactate (mmol/L)	10.7 (7.8–13.8)	13.8 (10.5–17.0)	<0.001
Cause of cardiac arrest (including autopsy findings)			
Acute coronary syndrome	89 (57%)	38 (38%)	<0.001
Coronary artery disease – chronic	29 (19%)	3 (3%)	
Pulmonary embolism	1 (1%)	23 (23%)	
Chronic heart failure	8 (5%)	6 (6%)	
Cardiomyopathy	7 (5%)	2 (2%)	
Myocarditis	5 (3%)	3 (3%)	
Aortic stenosis	5 (3%)	3 (3%)	
Aortic dissection type A	1 (1%)	3 (3%)	
Intracranial haemorrhage	1 (1%)	2 (2%)	
Bleeding – other	0 (0%)	3 (3%)	
Accidental hypothermia	3 (2%)	1 (1%)	
Pulmonary hypertension	0 (0%)	2 (2%)	
Sepsis	0 (0%)	1 (1%)	
Other	1 (1%)	1 (1%)	
Unknown	6 (4%)	9 (9%)	
Cause of death			
Refractory arrest	34/91 (37%)	46/94 (49%)	0.36
Brain death	14/91 (15%)	16/94 (17%)	
MODS	30/91 (33%)	22/94 (23%)	
Cardiogenic shock	9/91 (10%)	5/94 (5%)	
Unknown	3/91 (3%)	2/94 (2%)	
Bleeding	1/91 (1%)	3/94 (3%)	
WLST	18 (12%)	17 (17%)	0.29
Complications			
Bleeding -any	29/123 (24%)	17/62 (27%)	0.69
Fatal	1 (3%)	3 (18%)	0.23
Intracranial haemorrhage	6 (21%)	4 (24%)	
Overt	22 (76%)	10 (59%)	
Shock gut	44/123 (36%)	17/57 (30%)	0.54
Organ lacerations	1/132 (1%)	6/83 (7%)	0.03
Technical	2 (1%)	1 (1%)	1.00

Note: Data is expressed as median (IQR) or *N* (%). CPR – cardiopulmonary resuscitation; ROSC – recovery of spontaneous circulation; TTM – Target temperature management; ELCS – extracorporeal life support; MODS – multiorgan dysfunction syndrome; WLST – withdrawal of life-sustaining therapy.

Table 3 – Clinical outcome.

	All patients			Invasive therapy			Standard therapy		
Initial rhythm	Shockable (*N* = 156)	Non-shockable (*N* = 100)	*P*	Shockable (*N* = 72)	Non-shockable (*N* = 52)	*P*	Shockable (*N* = 84)	Non-shockable (*N* = 48)	*P*
Primary outcome									
Survival with CPC at 180 days									
1 or 2	63 (40%)	5 (5%)	<0.001	35 (49%)	4 (8%)	<0.001	28 (33%)	1 (2%)	<0.001
≥3	93 (60%)	95 (95%)		37 (51%)	48 (92%)		56 (67%)	47 (98%)	
Secondary outcomes									
Cardiac recovery at 30 days									
Yes	84 (54%)	15 (15%)	<0.001	43 (60%)	11 (21%)	<0.001	41 (49%)	4 (8%)	<0.001
No	72 (46%)	85 (85%)		29 (40%)	41 (79%)		43 (51%)	44 (92%)	
Neuro recovery at 30 days									
Yes	58 (37%)	4 (4%)	<0.001	34 (47%)	4 (8%)	<0.001	24 (29%)	0 (0%)	<0.001
No	98 (63%)	96 (96%)		38 (53%)	48 (92%)		60 (17%)	48 (100%)	

Note: Data is expressed as N (%). CPC – Cerebral Performance Category.

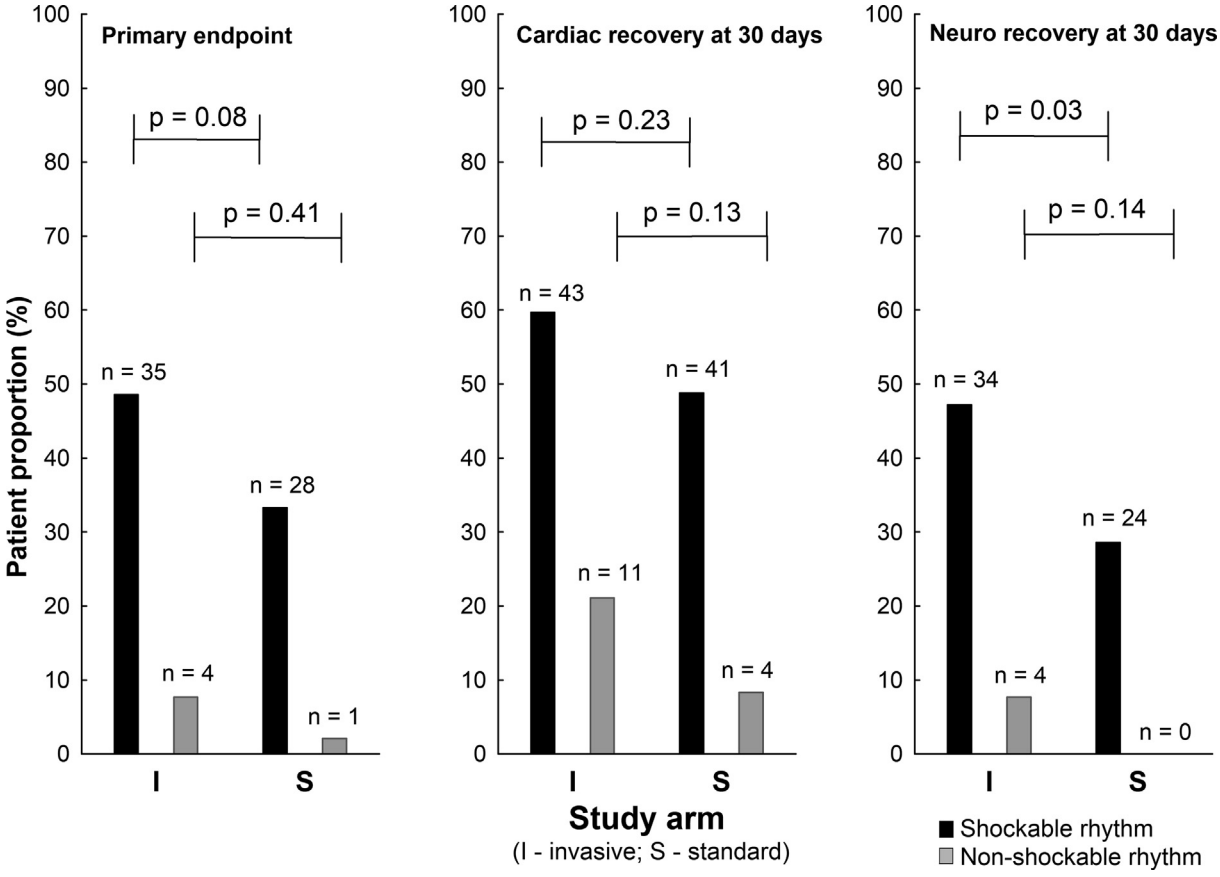

Fig. 1 – Clinical outcome of patients with shockable and non-shockable rhythm in standard and invasive treatment arms. Notes: A shockable rhythm had 72 patients in the invasive and 84 patients in the standard arm. A non-shockable rhythm had 52 patients in the invasive and 48 patients in the standard arm. Two-tailed Fisher's exact test. Presented p-values are for the superiority of the invasive arm (separately for a shockable and a non-shockable rhythm).

Table 4 – Cox regression analysis in the prediction of an unfavorable clinical outcome.

	Model A (Admitted to hospital) (n = 210)			Model B (After the initial in-hospital evaluation) (n = 181)		
Covariate	HR	95% CI	P	HR	95% CI	P
Age ≥ 65 years	0.92	0.63–1.34	0.67	0.87	0.57–1.34	0.53
Sex = women	0.96	0.62–1.49	0.86	1.17	0.73–1.85	0.52
Sustained ROSC on admission = yes	0.35	0.24–0.51	<0.001	0.69	0.41–1.15	0.15
Length CPR > 45 min = yes	–	–	–	1.97	1.16–3.32	0.01
Telephone assisted bystander CPR = yes	1.19	0.8–1.77	0.39	1.31	0.82–2.1	0.26
Acute coronary syndrome = yes	–	–	–	1.29	0.86–1.94	0.22
Shockable rhythm = yes	0.32	0.22–0.46	<0.001	0.27	0.18–0.41	<0.001

HR – hazard ratio; CI – confidence interval; ROSC – recovery of spontaneous circulation; CPR – cardiopulmonary resuscitation; ELCS – extracorporeal life support.

Discussion

This post-hoc analysis of the Prague OHCA study contains several important findings. A shockable initial rhythm is associated with a better chance of a 180 day-survival rate with a favorable neurological outcome, an improved secondary 30 day-neurological outcome and a 30 day-survival in refractory OHCA. This prognostically beneficial effect applies regardless of the invasive or standard treatment strategies used. The second important finding indicates that patients with an initial shockable rhythm who were treated with invasive strategy including ECPR more likely recovered their neurological function at 30 days.

Our findings for favorable outcomes in OHCA for those who presented with a shockable rhythm are not surprising and are in accordance with previously published data.[2,3,6] However, first, this analysis was based on a randomized population, and second, we enrolled truly refractory patients with prolonged resuscitations reaching 58 and 46 minutes in the invasive and standard arms with a reasonably overall favorable neurological survival.[15]

Currently, there is very limited data elucidating the impact of initial rhythm on the clinical outcome in refractory OHCA. Prior to the Prague OHCA study, only one small, randomized study focusing on refractory OHCA, which only considered patients manifesting a shockable rhythm, had been published.[20] Other non-randomised or retrospective studies also analysed prolonged and refractory OHCA. However, those only involved patients with shockable rhythms,[21,22] or included not only refractory CA,[11,23,24] or were performed in a cohort of in-hospital CA,[25] or the initial rhythm analysis was not shown.[26] Our data is in accordance with the retrospective analysis published by Kim et al.[27] In their study, which also included some patients treated with ECPR, an initial shockable rhythm seemed to be a favorable phenotype in patients with prolonged CA. One other retrospective study investigated the efficacy of rapid-response ECMO and intra-arrest coronary intervention in patients with CA which was complicated by acute coronary syndrome who were unresponsive to conventional CPR.[11] They observed a trend toward a higher rate of initial recorded shockable rhythm among patients who survived up to 30 days, but the difference was not statistically significant (68% versus 48%; p = 0.08). However, this study also enrolled non-OHCA patients.

Why are shockable rhythms better?

Patients who presented shockable rhythms represent > 85% of all CA survivors, probably due to a high prevalence of reversible causes of arrest.[28–30] It is generally accepted that the vast majority of VF arrests are related to an underlying cardiac disorder. Cardiac causes are less frequent in patients with asystole or PEA, even after excluding obvious non-cardiac causes such as a drug overdose, trauma, exsanguination, and primary respiratory failure.[31–33]

Our data showed overall higher number of declared prehospital death and death within the first hour after admission in patients with non-shockable rhythm. This is reflected in lower chance to achieve prehospital ROSC in patients with a non-shockable rhythm. The higher number of adrenalin doses and higher rate of organ lacerations most likely reflect difficulties during CPR and apprehension of inferior outcome of those patients. We speculate, that the absence of telephone assisted CPR might be a relevant cause of insufficient CPR and could therefore be linked to progression of some shockable rhythms to asystole. Target temperature management was less frequently applied in patients with a non-shockable rhythm. The reasons for non-starting or premature termination of target temperature management in our study (data not shown) are higher number of contraindications, mainly the haemodynamic instability.

Some authors considered VF to be a dependent rather than an independent variable and excluded initial rhythm from the logistic regression models.[6,34,35] It has been shown that variables which contributed to VF are similar to those covariates that predicted survival (i.e. bystander CPR, age, Firemen/Police-performed CPR, bystander-witnessed arrest).[6] However, in our study, the Cox regression analyses showed that an initial shockable rhythm was an independent predictor of survival with favorable neurological outcome similar to a shorter duration of CPR or a presence of sustained ROSC on admission. The inclusion of VF to the predictive models also has another purpose. In routine practice, the medical staff usually has very limited information about the patient's status and initial rhythm is one of very few available and easily recognisable parameters. Initial rhythm has also been identified as an independent parameter in some predictive models to rapidly determine the risk of the ischemic aetiology of CA.[36] All those aspects warrant the inclusion of initial rhythm to the final analysis. Acute coronary syndromes were responsible for a significant proportion of VF in the Prague OHCA

cohort. However, multivariable models did not identify acute coronary syndrome as an independent predictor of favorable outcome.

Some authors also reported that patients with non-shockable rhythms demonstrated poor overall outcomes, with the longest time-to-ROSC in a survivor of just less than 30 min.[3] Data from our standard arm showed that prolonged CPR in non-shockable rhythm does not yield more survivors. We have also shown, that ECPR in patients with a non-shockable rhythm does not improve survival with a good neurological outcome markedly. In contrast to patients with a non-shockable rhythm, our data have proven that patients with VF had better neurological recovery at 30 days when invasive approach including ECPR was applied. However, this encouraging secondary outcome was not followed with clearly higher neurologically favorable survival of VF patients after 180 days in the invasive arm most likely due to the fact, that the study was overall underpowered to show this difference.

Study limitations

The main limitation of this study was the single-centre design with limited sample size which does not allow us to study differences between PEA and asystole. This data is the post-hoc (not predefined) analysis. In some cases, the initial rhythm was not optimally recorded and easily analysable, and data were based on medical emergency system staff reports.

Conclusion

In the Prague OHCA study, an initial shockable rhythm is associated with neurologically favorable survival at 180 days even in prolonged refractory OHCA. The survival with favorable neurological outcome was not influenced by invasive treatment strategy. Non-shockable initial rhythms bear a poor prognosis in refractory OHCA even when ECPR is readily available.

Conflict of interest

None.

CRediT authorship contribution statement

Stepan Havranek: Conceptualization, Methodology, Writing – original draft. **Zdenka Fingrova:** Conceptualization, Methodology, Writing – original draft. **Daniel Rob:** Investigation, Data curation, Validation, Writing – review & editing. **Jana Smalcova:** Investigation, Data curation, Writing – review & editing. **Petra Kavalkova:** Investigation, Project administration, Data curation, Validation, Writing – review & editing. **Ondrej Franek:** Investigation, Data curation, Validation. **Ondrej Smid:** Investigation, Data curation. **Michal Huptych:** Formal analysis, Data curation. **Milan Dusik:** Investigation, Data curation, Validation. **Ales Linhart**: Writing - review & editing. **Jan Belohlavek:** Writing – review & editing, Supervision.

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