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Clinical paper

Passive leg raising in out-of-hospital cardiac arrest

Johan Holmén[a,*], *Johan Herlitz*[b], *Maria Jimenez-Herrera*[c], *Thomas Karlsson*[d], *Christer Axelsson*[e]

[a] *Department of Prehospital and Emergency Care, Department of Anaesthesiology and Intensive Care, Queen Silvia's Children's Hospital Sahlgrenska University Hospital, Sweden*

[b] *Centre for Prehospital Research, Faculty of Caring Science, Work Life and Social Welfare, University of Borås, Department of Cardiology, Sahlgrenska University Hospital, Sweden*

[c] *Department of Nursing, Universitat Rovira i Virgili Spain, Spain*

[d] *Health Metrics Unit, Institute of Medicine, Sahlgrenska Academy at University of Gothenburg, Sweden*

[e] *Centre for Prehospital Research, Faculty of Caring Science, Work Life and Social Welfare, University of Borås, Department of Prehospital and Emergency Care, Sahlgrenska University Hospital, Sweden*

Abstract

Background: The use of passive leg raising (PLR) in cardiopulmonary resuscitation (CPR) is sometimes discussed and even recommended. The effect of this intervention has never been properly addressed. We planned to determine whether PLR in out-of-hospital cardiac arrest (OHCA) is associated with an improved survival to 30 days.

Methods: In eight districts in western Sweden, we introduced PLR within five minutes after the start of CPR, among patients with OHCA. Patients in whom PLR was not performed, within the same district, served as a control group. Thirty-day survival was the primary endpoint. A propensity score analysis, as well as a standard multivariate analysis, was used to assess possible differences between the two groups.

Results: We identified 3554 patients with OHCA from the eight districts. Forty-four percent were treated with PLR during CPR. Patients who received PLR differed from those who did not, by having more risk factors for an adverse outcome (fewer crew-witnessed cases, more OHCA at home, a greater need for medication and prolonged delays to treatment). The overall survival to 30 days was 7.9% among patients who received PLR versus 13.5% among those who did not. A comparison of the groups, using propensity score matching, revealed a 30 -day survival of 8.6% in the PLR group versus 8.2% in the control group (odds ratio 1.07; 95% confidence interval 0.80–1.44).

Conclusion: In an observational study, we introduced PLR as an addition to standard treatment in patients with OHCA. We did not find any evidence that this treatment improves survival to 30 days.

Keywords: Cardiac arrest, OHCA (out-of-hospital cardiac arrest), CPR (cardiopulmonary resuscitation), Passive leg raising, Resuscitation, Cardiac arrest registry, The Swedish Registry for Cardiopulmonary Resuscitation

Introduction

The effect of passively raising the legs of the circulatory arrested patient receiving cardiopulmonary resuscitation (CPR) is not known. Older guidelines on prehospital CPR, have included passive leg raising (PLR), in both Sweden and the US.[1,2] Published recommendations are scarce[3] and, to our knowledge, there is no randomised controlled trial that addresses this question. In a swine-model, PLR has been shown to increase coronary perfusion

* Corresponding author.
E-mail address: johan.holmen@vgregion.se (J. Holmén).

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pressure before the first defibrillation.[4] Survival rates were found to be comparable between groups, but neurological 24 h-recovery was better for piglets whose lower body was elevated in a 45-° angle.

It has been indicated that PLR during CPR is associated with an increase in end-tidal CO_2 ($EtCO_2$) levels,[5] but its potential effects on survival have not been sufficiently investigated.

Not much work has been done to explore the possible effect PLR has on survival and cerebral function after OHCA in humans. We made a request to the Regional Ethical Review board, applying for permission to perform a randomised trial. The regional board was not in agreement, and the decision was made by The Central Ethical Review board of Sweden. The central board concludes that a beforehand consent is required by law, to perform procedures like PLR in unconscious patients.

Instead, The Central Review Board of Sweden suggested the implementation of PLR as a part of the routine procedure, followed by an observational evaluation (DNR Ö 11-2011). We therefore introduced a recommendation for PLR in OHCA in eight districts in Sweden and compared PLR-treated patients with a standard CPR procedure not including PLR.[6]

The primary aim of the study was to determine whether PLR, when added to standard treatment after OHCA, would increase survival to 30 days. Our hypothesis was that PLR, on top of standard treatment in the setting of OHCA, would increase the rate of survival to 30 days.

Methods

Planning and performance

In eight EMS (emergency medical service) districts, PLR within five minutes from the start of CPR was introduced in the CPR guidelines. The starting date was 1 April 2012 for five districts, 1 June 2012 for one district, 1 December 2012 for one district and 10 June 2013 for one district. The study ended on 31 March 2015 in all districts.

A monthly follow-up was conducted by e-mail, including a presentation of performance in each district. Performance was measured and reported as the number and proportion which received PLR, among all OHCA-patients in whom resuscitation was attempted. A high rate of compliance was encouraged and all the districts were ranked according to compliance with the study guidelines. Each month, attention focused on the top district with the largest proportion of PLR in OHCA treatment, to improve motivation and compliance.

EMS instructions and the PLR-method

An educational meeting was organised in each district, before the beginning of the study.

An instructional video was produced and distributed to EMS crews, prior to the introduction of PLR. In this video, the background was explained based on the work by Dragoumanos et al.[4] and the results from our earlier end-tidal CO_2 measurements during CPR.[5] These two studies formed the materials to aim at a 20–45-° hip joint flexion for the PLR manoeuvre.

Written instructions were distributed before the introduction of PLR, and re-distributed on a monthly basis together with the follow-up e-mails. The recommendation given was to use a chair, or any other object with a similar height, and place it under the patients' feet. The ambulance backpack was also proposed as a possible feet support, in the instructional video. Both methods result in a 20–45-° angle in the hip joint. We found in previous work that a 35 cm elevation of the heels from the floor, results in a 20 ° hip flexion in a 170–175 cm tall person.[5] The seat of a common chair places the feet around 45 cm above the floor.

The written instruction recommended immediate PLR, as a part of initiating CPR, or at least within five minutes from EMS arrival. If PLR was not performed within five minutes, the patient was registered as resuscitated without PLR. Passive leg raising was instructed to be maintained while the patient received CPR with chest compressions, and to be stopped when the patient regained circulation or when a decision was made to interrupt resuscitation attempts.

Mechanical chest compressions are commonly used in CPR by our EMS, and the Lund University Cardiopulmonary Assist System (LUCAS™) device has been used in the organisation for many years. All crew members are trained to use this device, but not all units carry the equipment. Normally, the dispatch centre alerts one crew with the shortest possible response time, and a second crew preferably carrying the LUCAS™ device. This procedure, and the fact that the first unit does not always carry the LUCAS™ equipment, means that mechanical chest compressions are sometimes applied late in the course.

Data collection

All data collection was made from the Swedish Registry for Cardiopulmonary Resuscitation (SRCR). Passive leg raising within five minutes from the start of CPR was introduced as a dichotomous variable within the register. We only included patients $>$18 and $<$110 years of age. For patients with more than one episode of CA, only the first episode was included.

The Swedish Registry for Cardiopulmonary Resuscitation - SRCR

The aim of the SRCR is to identify factors affecting survival and guide the development of cardiac arrest care. The SRCR is a national quality register covering almost 100% of patients with OHCA in Sweden in whom CPR is attempted.[7] It has been in existence since 1990. Registration is web-based and consists of one incidence part and a second follow-up part completed later than 30 days after the OHCA. The register includes the most important variables that affect the outcome after a cardiac arrest according to the Utstein criteria. Specifically for this study, we added the variable "PLR within five minutes" to the first part of the register, which was completed by the attending EMS personnel.

The cases in which PLR was initiated later than within five minutes from collapse, were regarded as being treated according to the standard CPR procedure without PLR.

Data were collected from the SRCR until 31 March 2015.

Statistical methods

For non-matched group comparisons Fisher's exact test was used for dichotomous variables and the Mann–Whitney U test for ordinal/continuous variables.

A propensity score for receiving PLR was constructed using backward selection in multiple logistic regression, with

$p < 0.30$ required to stay in the model. Candidate variables to be included in the score were: district, age, gender, initial arrhythmia, witnessed status, place of arrest, mechanical chest compressions, etiology, adrenaline treatment, intubation, amiodarone treatment and time from dispatch to EMS arrival. Of these, district, age, crew witnessed, home as location of CA, mechanical chest compressions, cardiac etiology, adrenaline treatment and intubation fulfilled $p < 0.30$ to stay in the model and were included in the score.

We also tested interactions between age and all the other above-mentioned variables and found that district 5, district 15, location of CA and intubation had $p < 0.30$ for interaction with age and also included these interaction terms in the score.

Patients were matched 1:1 according to whether PLR was administered using nearest- neighbour matching without replacement within a calliper of 0.20 standard deviations of the logit of the propensity score. The standardised difference, which is not influenced by sample size, was used as a balance diagnostic in the matched sample. McNemar's test and Wilcoxon's signed-rank test were used for significance testing regarding dichotomous and continuous/ordinal variables respectively, included in the propensity score between the matched groups. Other variables were compared using Fisher's exact test and the Mann–Whitney U test.

We also used the propensity score above as a covariate in a multiple logistic regression model, and performed an analysis using stratification by deciles of the propensity score. In addition, we performed a standard multivariate logistic regression analysis with the same variables as those included in the propensity score as covariates. All these final results are shown in Table 2, together with crude unadjusted results for all patients and for those patients with non-missing data for variables included in the propensity score.

In addition, due to the amount of missing data for several of the variables, multiple imputation was used in combination with a full model multivariable logistic regression analysis, including the same variables as included in the propensity score. Missing data was assumed to be missing at random and 50 imputed data sets were generated with the Markov Chain Monte Carlo method and using the expectation-maximization algorithm. Rubin's rules were used for pooling the results from the imputed data sets.

All tests are two-sided and p-values below 0.05 were considered statistically significant. All analyses were performed using SAS for Windows, version 9.4.

Results

During the study period, 3781 OHCA incidents were reported in the eight districts. One hundred and twenty-nine patients were excluded because of age (<18/>110 years old). In 76 cases, information was missing on whether or not PLR had been applied, and in another 22 cases, data on survival to 30 days were missing.

We identified 3554 cases of OHCA from the eight ambulance districts in western Sweden eligible for the study. In 44% of the patients, PLR was added (within five minutes) to the resuscitation procedure.

Survival to 30 days was 7.9% among patients who received PLR and 13.5% among those who did not (OR 0.55; 95% CI 0.44-0.69; $p < 0.0001$, Table 1)

Patients who received PLR differed from patients who did not receive PLR in a number of respects. First, the proportion of patients who received PLR differed between districts. Furthermore, patients who had PLR were less often crew witnessed but, on the other hand, they were more frequently bystander witnessed. They more frequently suffered an OHCA at home, had an OHCA with a cardiac etiology and more frequently received mechanical chest compressions. They more frequently received treatment with adrenaline and amiodarone and they were also more frequently intubated. Finally, they experienced a prolonged delay from collapse to calling for the EMS, from collapse to the start of CPR and from collapse to defibrillation.

Propensity score and matching

By using multiple logistic regression in a backward selection mode, with $p < 0.30$ for staying in the model, a propensity score was constructed. The identified variables included in the propensity score are presented in Table 2. Of all patients, n = 3273 had non-missing data for all these variables (Table 3). When matching 1:1 on the propensity score, the difference in 30-day survival between the two groups disappeared (OR 1.07 CI 0.80–1.44 p = 0.65). This matched comparison (Table 4) shows a 30-day survival rate of 8.6% in the PLR-group versus 8.2% in the group which received standard CPR treatment.

When using the propensity score as a regression adjustment, a similar result was found (OR 1.05 CI 0.81–1.37 p = 0.69, Table 2). Applying a multivariate adjustment of the same factors as those included in the propensity score (Table 2), produces very similar results (OR 1.07 CI 0.81–1.42 p = 0.64, Table 2).

In an attempt to further address the amount of missing data on several of the variables, we performed a complementary analysis with multiple imputations. This result did not deviate from the previous analysis (OR 1.1 CI 0.84–1.44 p = 0.51).

Discussion

We analysed patients in whom CPR was attempted, with and without PLR, after OHCA. The univariate analysis showed that survival to 30 days was higher in the group in which PLR was not applied (13.5% versus 7.9%). Several possible confounding factors were unequally distributed in the two groups and could, at least to some extent, explain our finding. When adjusting for these factors, by using both a propensity score analysis and standard multivariate analysis, there was no statistically significant difference in 30-day survival between the two groups.

The intervention with PLR was performed in only 44% of the patients who were eligible for the intervention. The mechanism behind this limited adherence to the new guidelines can only be speculated upon. It is possible that the situations perceived by the EMS crews as very critical and stressful led to PLR not being prioritised or remembered to the same extent as in situations perceived as less urgent. Younger patients with short delays to treatment would then be more likely not to receive PLR.

A 44% compliance to PLR guidelines is poor. It is possible that a more extensive information to the EMS crews would have been required. Training and education in CPR has a long tradition in Sweden, and the national guidelines are well implemented and known to all crews. Any change in these guidelines, as adding a PLR manoeuvre, needs thorough anchoring to be accepted. A more detailed discussion on the purpose of PLR, and the importance of this study, could have improved compliance.

Table 1 – All OHCA-patients in the eight districts, with information on survival to 30 days.

	All patients (n = 3554)	PLR (n = 1551)	No PLR (n = 2003)	p-Value	stzd diff
Disctrict (%)					
1 – Kungälv	5.3	5.7	4.9	0.29	0.04
5 – SÄS	13.1	15.5	11.1	0.0001	0.13
11 – NU-sjukvården	13.3	12.4	13.9	0.18	0.05
12 – SU	15.4	15.9	15.0	0.51	0.02
13 – SkaS	12.3	12.9	11.8	0.33	0.03
15 – Halland	12.0	13.8	10.7	0.005	0.10
16 – Dalarna	15.9	14.2	17.3	0.01	0.08
35 – Värmland	12.8	9.6	15.3	<0.0001	0.17
Age (years, median and 10th–90th percentile)	71 (49–87)	72 (50–87)	70 (47–87)	0.005	0.10
Female gender (%)	34.2	33.8	34.4	0.69	0.01
VF as initial arrhythmia (%), (29/93)[g]	22.5	22.4	22.5	0.97	0.00
Witnessed status (%), (22/55)[g]					
Crew witnessed	15.4	12.6	17.7	<0.0001	0.14
Bystander witnessed	51.3	54.5	48.8	0.0008	0.12
Witnessed, but unknown whether by crew or bystander	1.1	1.0	1.1	1.00	0.00
Not witnessed	32.2	31.9	32.4	0.71	0.01
OHCA taking place at home (%)	70.4	76.4	65.8	<0.0001	0.24
CPR before arrival of EMS[a] (%) (9/17)[g]	72.1	70.4	73.5	0.07	0.07
Mechanical chest compresssions (%)	46.9	55.9	40.1	<0.0001	0.32
Cardiac etiology (%), (56/165)[g]	62.0	64.9	59.6	0.002	0.11
Treatment (%)					
Adrenalin	80.6	89.0	74.1	<0.0001	0.39
Intubation	27.5	30.9	24.8	<0.0001	0.14
Amiodarone	12.7	14.6	11.2	0.003	0.10
Defibrillation[b]	96.2	98.5	94.4	0.003	0.22
Median no. of defibrillations[c] (2/0)[g] and 10th–90th percentile	3 (1–8)	3 (1–8)	3 (1–8)	0.001[d]	0.24
Delay (minutes, median and 10th–90th percentile)					
Collapse to call for EMS[e] (411/602)[g]	2 (0–9)	2 (0–9)	2 (0–9)	0.007[d]	0.14
Collapse to start of CPR[e] (99/192)[g]	1 (0–15)	2 (0–15)	1 (0–14)	<0.0001	0.22
Collapse to first defibrillation[f] (24/40)[g]	11 (0–23)	13 (3–24)	10 (1–23)	0.0002	0.33
Call for EMS to EMS arrival (29/67)[g]	10 (5–22)	10 (5–21)	11 (5–24)	0.02	0.08
Survival at 30 days (%)					
All patients	11.1	7.9	13.5	<0.0001	
Patients found in ventricular fibrillation	33.6	24.3	40.9	<0.0001	
Patients with other initial arrhythmia	3.6	3.0	4.1	0.18	

[a] Of those not witnessed or bystander witnessed (n = 1321/1582).
[b] Of those with ventricular fibrillation as initial arrhythmia (n = 341/430).
[c] Of those defibrillated with ventricular fibrillation as initial arrhythmia (n = 336/406).
[d] More/longer for PLR-group.
[e] Of witnessed cases (n = 1042/1316).
[f] Of defibrillated witnessed cases with ventricular fibrillation as initial arrhthmia (n = 274/346).
[g] Number of patients with missing information in the two groups, respectively.

The marked imbalance between the two groups in terms of various factors at resuscitation impaired the opportunity fully to address the eventual potential of PLR. Most of the imbalance favoured the patients who did not receive PLR, including more crew-witnessed cases, fewer cases that took place at home, longer delays to treatment and a greater need for drugs, intubation and mechanical chest compressions. As a result, the group of patients who received PLR became a high-risk.

The above findings, among other factors, may be explained by the fact that PLR became an extra burden for the EMS crew and delayed

Table 2 – 30-day survival – PLR versus no PLR.

30-day survival, PLR versus no PLR	n	OR	95% CI	p-Value
Crude model (all pts)	3554	0.55	0.44–0.69	<0.0001
Crude model (propensity score pts)	3273	0.53	0.42–0.67	<0.0001
Multivariable model	3273	1.07	0.81–1.42	0.64
Matched on propensity score	2524	1.07	0.80–1.44	0.65
Regression adjusted for propensity score				
Propensity score continous	3273	1.05	0.81–1.37	0.69
Propensity score deciles	3273	1.04	0.80–1.36	0.76

Variables included in propensity score (logistic regression, backward selection, $p < 0.30$ for staying in the model).
District.
Age.
Crew witnessed.
Home as place of CA.
Mechanical chest compression.
Cardiac etiology.
Adrenalin treatment.
Intubation treatment.
Interaction district 5-age.
Interaction district 15-age.
Interaction place-age.
Interaction intubation-age.
The multivariate analysis included the same variables as the propensity score.

other interventions, such as defibrillation. The greater need for adrenaline, intubation and mechanical chest compressions in the PLR group may indicate that some patients had a rapid return of spontaneous circulation and thereby escaped PLR. As a result, PLR was selected for the "worst-case scenarios". The findings described above could, at least to some extent, explain the higher survival rate among patients who did not receive PLR.

We tried to adjust for the imbalance between the two groups, regarding different factors at resuscitation, using various statistical approaches. They all yielded the result that we were unable to find any evidence of a difference in survival to 30 days after receiving PLR. Our hypothesis that PLR increases survival to 30 days could not be confirmed.

The present study hypothesis was based on a previous pilot study from Gothenburg,[5] concluding that a 20° leg elevation during CPR increases the levels of $EtCO_2$ during CPR. Our hypothesis was that the higher levels of $EtCO_2$ could be a result of PLR promoting venous return and augmenting artificial circulation during external cardiac compressions. We furthered hypothesised that PLR could cause improved coronary perfusion pressure (CPP) and thereby possibly a greater chance of survival.

Parts of this hypothesis is extrapolated from intensive care units and anaesthetised patients.[8,9] In simulation modelling, it has been indicated that PLR increases cerebral perfusion[10] and, as already mentioned, coronary perfusion has been shown to increase from PLR in arrested piglets.[4]

It is possible to speculate about the optimal degree of PLR for it to be effective. We do not know whether the results would have been different if PLR had been performed at an angle other than the 20–45° we applied.

The EMS crews were instructed to perform immediate PLR, or at least PLR within five minutes. It is important to consider that adherence to this time limit is unknown, as well as the possibility that some patients could have received PLR later than within five minutes after EMS arrival, but were incorrectly registered as treated with PLR.

We cannot exclude that PLR performed even earlier after collapse, or with a more aggressive angle (>45°) could be beneficial, even in our system. The EMS response time, as well as the practical difficulties in performing a standardized PLR of > 45°, has to be taken into account when considering the future of PLR in OHCA. However, earlier PLR, with a higher degree of hip flexion, would be very challenging to perform and evaluate within our ambulance system.

In our population, we did not find any indication of a benefit from PLR during CPR. We cannot exclude the possibility that PLR could be beneficial if performed earlier after collapse, or if started already by bystander rescuers.

Strengths and limitations

The strength of the study is that we included a large number of patients from a well-defined area and from a well-controlled register in which all the patients who were eligible for the study were reported. The representativeness of the study cohort is therefore very high.

The main drawback is the imbalance between the two groups at baseline. Furthermore, we can only speculate on the possible mechanisms behind the low rate of adherence to the introduction of PLR in the guidelines.

Another major concern is the amount of missing data, resulting in a reduction of cases included in the propensity score compared with the crude model.

Yet another concern is the lack of information on the time from collapse to PLR. Even though the recommendation was to initiate CPR with PLR, we were not able to verify that PLR was actually performed before the other CPR interventions. Further, information is missing on the number of patients who had PLR, but too late (>five minutes) in the course of resuscitation and were therefore registered as not having PLR.

One possible confounding factor, which was not measured and could therefore not be adjusted for, was patient co-morbidity.

Table 3 – All patients with complete data on the variables included in the propensity score.

	All patients (n = 3273)	PLR (n = 1476)	No PLR (n = 1797)	p-Value	stzd diff
Disctrict (%)					
1 – Kungälv	5.2	5.6	4.8	0.34	0.04
5 – SÄS	13.5	15.7	11.7	0.0008	0.12
11 – NU-sjukvården	12.3	12.1	12.5	0.75	0.01
12 – SU	15.4	15.8	15.1	0.63	0.02
13 – SkaS	11.4	12.8	10.2	0.02	0.08
15 – Halland	12.3	13.8	11.1	0.02	0.08
16 – Dalarna	16.5	14.5	18.1	0.006	0.10
35 – Värmland	13.4	9.7	16.5	<0.0001	0.20
Age (years, median and 10th–90th percentile)	71 (49–87)	72 (51–87)	70 (48–88)	0.007	0.10
Female gender (%)	33.8	33.8	33.8	1.00	0.03
VF as initial arrhythmia (%), (25/73)[g]	22.5	21.9	22.9	0.52	0.02
Witnessed status (%)					
Crew witnessed	15.5	12.5	17.9	<0.0001	0.15
Bystander witnessed	51.8	54.5	49.7	0.007	0.10
Witnessed, but unknown whether by crew or bystander	1.0	1.1	1.0	0.86	0.01
Not witnessed	31.7	32.0	31.4	0.73	0.01
OHCA taking place at home (%)	70.9	77.2	65.7	<0.0001	0.26
CPR before arrival of EMS[a] (%), (9/13)[g]	72.2	70.4	73.7	0.06	0.07
Mechanical chest compresssions (%)	47.3	56.0	40.1	<0.0001	0.32
Cardiac etiology (%)	62.3	65.0	60.2	0.005	0.10
Treatment (%)					
Adrenalin	81.0	89.1	74.4	<0.0001	0.39
Intubation	28.0	31.2	25.3	0.0002	0.13
Amiodarone	12.8	14.6	11.3	0.005	0.10
Defibrillationb[b]	96.4	98.4	94.7	0.008	0.21
Median no. of defibrillations[c] (2/0)[g] and 10th–90th percentile	3 (1–8)	3 (1–8)	3 (1–8)	0.006[d]	0.21
Delay (minutes, median and 10th–90th percentile)					
Collapse to call for EMS[e] (391/531)[g]	2 (0–9)	2 (0–9)	2 (0–9)	0.01[d]	0.14
Collapse to start of CPR[e] (90/139)[g]	1 (0–15)	2 (0–15)	1 (0–14)	<0.0001	0.22
Collapse to first defibrillation[f] (20/28)[g]	11 (0–23)	13 (3–24)	11 (1–23)	0.0003	0.32
Call for EMS to EMS arrival (28/60) [g]	10 (5–22)	10 (5–21)	11 (5–24)	0.10	0.06
Survival at 30 days (%)					
All patients	10.9	7.7	13.6	<0.0001	
Patients found in ventricular fibrillation	33.4	23.6	41.3	<0.0001	
Patients with other initial arrhythmia	3.6	3.1	4.1	0.23	
Propensity score					
Median	0.47	0.50	0.43	<0.0001	
10th–90th percentile	0.25–0.61	0.31–0.62	0.22–0.60		
Min-max	0.09–0.72	0.13–0.72	0.09–0.72		

[a] Of those not witnessed or bystander witnessed (n = 1276/1457).
[b] Of those with ventricular fibrillation as initial arrhythmia (n = 318/395).
[c] Of those defibrillated with ventricular fibrillation as initial arrhythmia (n = 313/374).
[d] More/longer for PLR-group.
[e] Of witnessed cases (n = 1004/1233).
[f] Of defibrillated witnessed cases with ventricular fibrillation as initial arrhthmia (n = 260/329).
[g] Number of patients with missing information in the two groups, respectively.

Table 4 – Patients matched on propensity score.

	All patients (n = 2524)	PLR (n = 1262)	No PLR (n = 1262)	p-Value	stdz diff
Disctrict (%)					
1 – Kungälv	5.4	5.4	5.5	0.93	0.004
5 – SÄS	14.5	14.1	14.8	0.55	0.020
11 – NU-sjukvården	13.0	13.2	12.8	0.75	0.012
12 – SU	15.6	15.6	15.6	1.00	0.000
13 – SkaS	11.6	11.5	11.7	0.84	0.007
15 – Halland	12.5	12.6	12.4	0.89	0.005
16 – Dalarna	16.5	16.3	16.7	0.76	0.011
35 – Värmland	10.9	11.3	10.5	0.41	0.028
Age (years, median and 10th–90th percentile)	72 (50–88)	72 (50–87)	72 (50–88)	0.98	0.008
Female gender (%)	34.5	34.3	34.7	0.84	0.008
VF as initial arrhythmia (%), (23/29)[g]	21.3	21.6	21.0	0.73	0.015
Witnessed status (%),					
Crew witnessed	14.1	13.5	14.7	0.37	0.034
Bystander witnessed	53.2	54.2	52.3	0.33	0.038
Witnessed, but unknown whether by crew or bystander	1.1	1.0	1.2	0.69	0.015
Not witnessed	31.5	31.2	31.8	0.77	0.012
OHCA taking place at home (%)	73.2	73.9	72.4	0.28	0.034
CPR before arrival of EMS[a] (%), (7/12)[g]	70.7	69.5	71.9	0.23	0.053
Mechanical chest compresssions (%)	50.9	50.7	51.1	0.80	0.008
Cardiac etiology (%)	63.1	63.1	63.2	0.96	0.002
Treatment (%)					
Adrenalin	87.3	87.2	87.4	0.85	0.005
Intubation	29.2	29.4	28.9	0.77	0.010
Amiodarone	13.8	13.8	13.9	0.95	0.002
Defibrillation[b]	97.3	98.1	96.5	0.29	0.010
Median no. of defibrillations[c] (2/0)[g] and 10th–90th percentile	3 (1–8)	3 (1–8)	3 (1–9)	0.34	0.084
Delay (minutes, median and 10th–90th percentile)					
Collapse to call for EMS[d] (350/346)[g]	2 (0–9)	2 (0–9)	2 (0–10)	0.11	0.100
Collapse to start of CPR[d] (81/89)[g]	2 (0-15)	2 (0–15)	1 (0–15)	0.12	0.079
Collapse to first defibrillation[e] (18/18)[g]	12 (2–25)	13 (3–24)	12 (1–26)	0.58	0.055
Call for EMS to EMS arrival (25/33)[g]	10 (5–22)	10 (5–21)	10 (5–22)	0.41	0.033
Survival at 30 days (%)					
All patients	8.4	8.6	8.2	0.65	
Patients found in ventricular fibrillation	27.1	26.1	28.2	0.62	
Patients with other initial arrhythmia	2.9	3.6	2.3	0.08	
Propensity score					
Median	0.49	0.49	0.49	0.18	
10th–90th percentile	(0.30–0.61)	(0.30-0.61)	(0.30–0.61)		
Min-max	(0.13–0.72)	(0.13–0.72)	(0.13–0.72)		

[a] Of those not witnessed or bystander witnessed (n = 1078/1061).
[b] Of those with ventricular fibrillation as initial arrhythmia (n = 268/259).
[c] Of those defibrillated with ventricular fibrillation as initial arrhythmia (n = 263/250).
[d] Of witnessed cases (n = 868/861).
[e] Of defibrillated witnessed cases with ventricular fibrillation as initial arrhthmia (n = 220/217).
[g] Number of patients with missing information in the two groups, respectively.

Conclusion

Among patients with OHCA in western Sweden in whom CPR was attempted, we introduced PLR within five minutes from EMS arrival as an additional treatment to standard care. EMS-crews were able to perform the PLR intervention in 44% of the OHCA cases. We did not find that the addition of this treatment improved survival to 30 days.

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REFERENCES

1. Standards and guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ecc). JAMA 1980;244:453–509.
2. Standards for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC). II. Basic life support. JAMA 1974;227:841–51.
3. Obisike VL, Tamayo E, Heredia-Rodriguez M. Passive leg raising in CPR: increasing the effectiveness of each compression. Resuscitation 2016;101:e15.
4. Dragoumanos V, Iacovidou N, Chalkias A, et al. Passive leg raising during cardiopulmonary resuscitation results in improved neurological outcome in a swine model of prolonged ventricular fibrillation. Am J Emerg Med 2012;30:1935–42.
5. Axelsson C, Holmberg S, Karlsson T, Axelsson AB, Herlitz J. Passive leg raising during cardiopulmonary resuscitation in out-of-hospital cardiac arrest–does it improve circulation and outcome? Resuscitation 2010;81:1615–20.
6. Axelsson C, Jimenez-Herrera M, Holmén J, Azeli Y, Herlitz J. Could passive leg raising (PLR) during CPR improve survival in out-of-hospital cardiac arrest. Resuscitation 2017;118:e20–1.
7. Herlitz J. Swedish cardiac arrest registry - annual report 2017. (Accessed February 16, 2018, at. . http://www.hlr.nu/wp-content/uploads/svenska-hlr-registret-arsrapport-2017.pdf.
8. Aneman A, Sondergaard S. Understanding the passive leg raising test. Intensive Care Med 201642: 1493-149.
9. Monnet X, Marik P, Teboul J-L. Passive leg raising for predicting fluid responsiveness: a systematic review and meta-analysis. Intensive Care Med 2016;42:1935–47.
10. Zhang Y, Jiménez-Herrera M, Axelsson C, Cheng Y. Not bad: passive leg raising in cardiopulmonary resuscitation-a new modeling study. Front Physiol 2016;7:665.