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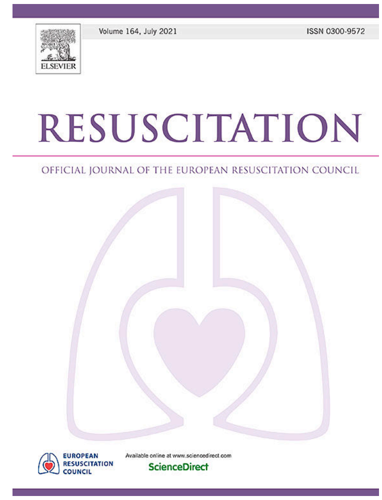

Clinical paper

Live video from bystanders' smartphones to improve cardiopulmonary resuscitation

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Live video from bystanders' smartphones to improve cardiopulmonary resuscitation

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Keywords:

cardiopulmonary resuscitation, out-of-hospital cardiac arrest, cardiac arrest, dispatcher, emergency call, video, technology.

Abbreviation list:

OHCA: Out-of-hospital cardiac arrest

CPR: Cardiopulmonary resuscitation

DA-CPR: Dispatcher-assisted cardiopulmonary resuscitation

AED: Automated external defibrillator

Abstract

Aim

To investigate whether live video streaming from the bystander's smartphone to a medical dispatcher can improve the quality of bystander cardiopulmonary resuscitation (CPR) in out-of-hospital cardiac arrest (OHCA).

Methods

After CPR was initiated, live video was added to the communication by the medical dispatcher using smartphone technology. From the video recordings, we subjectively evaluated changes in CPR quality after the medical dispatcher had used live video to dispatcher-assisted CPR (DA-CPR). CPR quality was registered for each bystander and compared with CPR quality after video-instructed DA-CPR. Data were analysed using logistic regression adjusted for bystander's relation to the patient and whether the arrest was witnessed.

Results

CPR was provided with live video streaming in 52 OHCA calls, with 90 bystanders who performed chest compressions. Hand position was incorrect for 38 bystanders (42.2%) and improved for 23 bystanders (60.5%) after video-instructed DA-CPR. The compression rate was incorrect for 36 bystanders (40.0%) and improved for 27 bystanders (75.0%). Compression depth was incorrect for 57 bystanders (63.3%) and improved for 33 bystanders (57.9%). The adjusted odds ratios for improved CPR after video-instructed DA-CPR were; hand position 5.8 (95% CI: 2.8–12.1), compression rate 7.7 (95% CI: 3.4–17.3), and compression depth 7.1 (95% CI: 3.9–12.9). Hands-off time was reduced for 34 (37.8%) bystanders.

Conclusions

Live video streaming from the scene of a cardiac arrest to medical dispatchers is feasible. It allowed an opportunity for dispatchers to coach those providing CPR which was associated with a subjectively evaluated improvement in CPR performance.

Introduction

Dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) increases the overall provision rate of bystander cardiopulmonary resuscitation (CPR) and improves survival from out-of-hospital cardiac arrest (OHCA).[1,2] The quality of CPR is important[3] and performance is estimated to be poor in 20–70% of OHCA cases assessed by ambulance staff on arrival[4,5] or analysed from defibrillators applied to patients by the bystanders.[6] DA-CPR is currently provided through a standard telephone audio-call between caller and the medical dispatcher. Analyses of closed-circuit television (CCTV) recordings from the location of OHCA has shown a difference between what the medical dispatcher thought was going on and what actually happened.[7,8] Improved mobile phone technology has made video-calls or live video transmissions more widespread and efficient, meaning that dispatchers can guide while watching the scene. In Seoul, a video-instructed DA-CPR protocol has been implemented.[9] Survival outcome was better in the video-instructed group than in the audio-instructed group. However, adjusted for age of the patients, location, and whether the cardiac arrest was witnessed by bystanders, there was no statistically significant difference. No previous studies examined whether video-instructed DA-CPR can improve the quality of CPR in real OHCA situations.

We aimed to investigate whether live streaming using bystander's smartphone to the medical dispatcher could improve the quality of bystander CPR in real OHCA cases. Our primary outcome was improvement of compressions (hand position, compression rate, compression depth, recoil of the chest, and whether the arms were stretched). We also analysed reduction in hands-off time, provided ventilation, and automated external defibrillator (AED) guidance.

Methods

Setting

The study was conducted at Copenhagen Emergency Medical Services in Denmark, which covers an area of 2,559 km^2 and with approximately 1.8 million people. More than 88% of adults in Denmark own a video-capable smartphone. [10] There is a single emergency phone number (1-1-2) to a call centre. If the problem is medical, the call is re-directed to the Emergency Medical Dispatch Centre, where medical dispatchers answer. The medical dispatchers are specially trained registered nurses and paramedics with experience within emergency care. They have all completed a Basic Life Support course and an advanced course in DA-CPR. The medical dispatcher is trained to start every call by clarifying whether the patient is conscious and breathing normally. If OHCA is suspected, the medical dispatcher follows a guideline for dispatcher-assisted cardiopulmonary resuscitation based on the European Resuscitation Council Guidelines for Resuscitation. [11] From June 2019, all medical dispatchers have been able to add live video to the emergency call with a text message link sent to the caller's smartphone using the prehospital platform GoodSAM® Platform Instant-on-scene (www.goodsamapp.org, London, Great Britain). [12,13] After confirmation from the bystander, the smartphone automatically starts transmitting a secure video live stream from the emergency scene to the medical dispatcher while continuing the audio call. The loudspeaker function must be activated if the same phone is used for the emergency call and live video transmission.

Live video and CPR guidance

A retrospective study was conducted with follow-up on OHCA cases where video was added to the communication. All medical dispatchers received a half-day training course in adding live video to the emergency calls before participation. The training included simulation-based scenarios with unconscious patients and cardiac arrest cases with a focus on high-quality CPR with simultaneously real-time guidance (video-instructed DA-CPR). When medical dispatchers received an OHCA-suspected call, they first initiated bystander CPR using the already connected audio call to prevent delayed chest compressions. Afterwards, the medical dispatcher asked whether more than two bystanders were present and whether a video-capable smartphone was available. If both conditions were met, the medical dispatcher added live video to the emergency call. According to the video-instructed flow chart (Appendix 1), the medical dispatcher primarily evaluated the correctness of hand position, compression rate, compression depth, and whether chest recoil was present. Based on this information, the medical dispatcher guided when necessary (video-instructed DA-CPR).

All medical dispatchers had a metronome available to support their guidance in compression rate. Guidance was given until ambulance arrival.

Data collection and outcome

The dispatch system marked whether a live video had been used and the cause of the call. Further details about the implementation can be found in another study. [14] The audio and video recording were combined for the analysis. All suspected OCHA cases where CPR continued or started after the live video transmission had begun were included. Excluded were OHCA cases where CPR ended before video-instructed DA-CPR.

Raters subjectively analysed the quality of CPR from the video recordings before and after the medical dispatcher had delivered video-instructed DA-CPR.

The first evaluation of the CPR quality was done as soon as possible from the live video, and the second evaluation was done after the video-instructed DA-CPR when the CPR was optimised as much as possible. The evaluation was done by a physician (GL) and a European Resuscitation Council certified Basic Life Support instructor (OR). In case of disagreement between the two observers, a third person (HC) was included to assess the CPR quality.

Measurements of the CPR quality were: hand position (the heel of one hand in the centre of the chest, with the other hand on top),[11] compression rate between 100–120 per min, compression depth (5–6 cm, or approximately one-third of the anterior-posterior diameter), chest wall recoil (complete recoil of the chest wall between chest compressions), arms stretched (visibly straightened elbow joints), hands-off time (the medical dispatcher actively minimised Hands-off time and delays in CPR (yes/no)), and correct performed rescue breaths (visibly rise of the chest). Registration of the CPR performance before video-instructed DA-CPR was recorded as "correct", "not correct" or "not available". After video-instructed DA-CPR the registration was evaluated as "correct", "not correct", "improved- not correct", "not correct", "not correct – worsened" or "not available". Compressions depth could be difficult to evaluate and we included the category "improved-not correct". Reduction in hands-off time was registered during the entire video recording and not only before and after video-instructed DA-CPR. Secondary, the use of an automated external defibrillator (AED) and whether the bystanders had instructions were recorded and described. For all parts of the video, it was registered whether the medical dispatcher tried to optimise the quality of CPR (giving guidance/instructions). The duration of the CPR, the shift of person performing CPR, and whether the victim had signs of live or agonal breathing were also registered. All registrations were determined from either the video or the emergency call.

Approval and ethics

The study was approved by the Danish Data Protection Agency (P-2020-656) and registered at ClinicalTrial.gov (NCT04061187). The study group applied for ethical approval from The Danish National Committee on Health Research Ethics (VEK 16038443), but formal approval was waived. Callers had to give consent and inform other bystanders that live video was being added to the emergency call.

Statistical analyses

Data were analysed using descriptive statistics by frequencies (N) and percentages (%). According to a sample size calculation, 53 bystanders who had video-instructed DA-CPR were needed to evaluate an improvement in good-quality CPR from 50% to 70% after video-instructed DA-CPR (McNemar's method, type 1 error rate 5%, power 80%), including the addition of 20% due to uncertainty of our estimates. The calculation was based on including only first-person performing CPR. We subsequently decided to evaluate the CPR quality of all bystanders performing CPR. Change in CPR quality for each CPR measure was divided into a dichotomous variable: "correct" and "improved but not correct", or "not correct" and "not-correct – worsened" of the CPR quality.

We used adjusted logistic regression with repeated measurements modelled using the Generalised Estimating Equations approach, with an exchangeable correlation structure for each individual. We adjusted for the bystander's relation to the patient ("relative/friend", "stranger" or "healthcare/nursing home employees/volunteer citizen first responder") and whether the cardiac arrest was witnessed by the bystander. If the information was not applicable, it was excluded from the analysis. A 5% significance level was applied. All analyses were performed using SAS Enterprise Guide version 7.1 statistical software (SAS Institute Inc., Cary, NC, USA).

Results

CPR data were provided from 52 OHCA videos, in which 90 bystanders perform chest compressions with a live video stream (37 more bystanders than needed according to the power calculation). Thirteen cases were excluded because the patient was alive, and the CPR ended before the live video stream. In four cases, there were conclusive signs of death, which were evaluated by the physician on duty at the Emergency Medical Dispatch Centre. The flow chart is illustrated in Figure 1.

(Insert Figure 1: Flow diagram of live video transmission from bystanders' smartphones to the medical dispatchers in case of cardiac arrest)

Among the included 90 bystanders were four OHCA cases, where CPR started after the live video transmission had begun. Six bystanders experienced signs of life from the cardiac arrest patient during CPR. Five patients started moving, one patient had open eyes, and three patients uttered sound. Agonal breathing was present in 14 (26.9%) patients some time during the video.

Most cardiac arrests were presumed medical etiology. The OHCA happened at a public location in 57.7% of the cases. The bystanders initiated CPR in half of the cases before any guidance from the medical dispatcher. Description of the OHCA cases are presented in Table 1.

(Insert Table 1. Description of 52 out-of-hospital cardiac arrest cases where live video was used during the emergency call, and 90 bystanders provided cardiopulmonary resuscitation.)

In 21 OHCA cases (40.4%) the loudspeaker function was not activated because the communications were made with two smartphones; one cell phone for the audio-call and one for the video transmission. In these cases, the caller had to forward the CPR instructions to the rescuer.

CPR quality

Hand position was correct for 50 (55.6%) of the bystanders, compression rate was correct for 45 (50.0%), and compression depth was correct for 19 (21.1%) of the bystanders before video-instructed DA-CPR started (Table 2) evaluated subjectively from the video recordings.

(Insert Table 2: The quality of cardiopulmonary resuscitation before and after medical dispatchers used video to assist in cardiopulmonary resuscitation for 90 bystanders.)

Once the video instruction had started correct or improved CPR was shown in 73 cases (81.1%) for hand position, 70 (77.7%) for compression rate, and 53 (58.9%) for compression depth.

The CPR quality after video-instructed DA-CPR is illustrated in Figure 2.

(Insert Figure 2. The quality for bystander Cardiopulmonary resuscitation before and after Video-instructed dispatcher-assistant cardiopulmonary resuscitation.)

The subjective evaluation of CPR quality improved after video-instructed DA-CPR for 60.5% (95% CI: 43.4–76.0) of the bystanders with incorrect hand position, 75.0% (95% CI: 57.8–87.9) of bystanders with incorrect compression rate, and 57.9% (95% CI: 44.0–70.9) with incorrect compression depth. In one case, the rate of compressions was too fast after video-instructed DA-CPR. Correction of recoil was not done for 21 bystanders, where the bystander leaned on the chest and there was no adequate rise of the chest between compressions. The cases where CPR was not improved are described in table 3.

(Insert Table 3: Description of out-of-hospital cardiac arrest cases where the quality of the cardiopulmonary resuscitation was not improved after Video-instructed Dispatcher-assisted cardiopulmonary resuscitation.)

Hands-off time was minimised for 34 (38%) bystanders. Ventilation was performed in 25 OHCA cases (48%), but the ventilation could only be evaluated for six bystanders. It was difficult to evaluate whether the chest raised during a rescue breath.

The odds ratios for good (correct or improved CPR) after video-instructed DA-CPR reached statistical significance for hand position, compression rate, compression depth, and whether the bystander performing the CPR had stretched arms (Table 4).

(Insert Table 4. The odds ratio for correct or improved cardiopulmonary resuscitation after Video-instructed Dispatcher-assisted cardiopulmonary resuscitation).

Gathering parameters for performed compression (hand position, rate, depth, and recoil) for bystanders with all parameters available for evaluation (n=69), 8 (11.6%) were correct before video-instructed DA-CPR compared to 30 (43.5%) afterwards. None of the bystanders performed insufficiently on all parameters after video-instructed DA-CPR.

We found that 18 bystanders (20.0%) stopped because insufficient CPR was provided and another bystander took over. Such a change-over was suggested by the medical dispatcher in nine cases. In some situations, the medical dispatcher did not guide in all CPR issues. In other situations, the bystander did not follow instructions, for instance, "press harder".

Automated external defibrillator (AED)

In 23 OHCA cases, an AED arrived before the ambulance services. Twenty bystanders used an AED with a metronome, but two of those bystanders did not follow the metronome and applied compressions too fast. For one bystander with an available metronome, the compression rate was not available. In two OHCA cases, the medical dispatcher guided in how to use the AED, and in two other OHCA cases, the AED was not used before the arrival of the ambulance.

Discussion

Live video stream from smartphones to the medical dispatcher is a new area for a potential improvement of bystander CPR. In our explorative study, we found that live video streaming to medical dispatchers was feasible. The dispatchers could guide bystanders providing CPR which was associated with a subjectively evaluated improvement of bystander's hand position, compression rate, compression depth, and arms stretched after live video was added to the communication. Hands-off time was reduced in one-third of cases. The only parameter that did not improve was chest recoil.

Our results correspond to a simulation study conducted by Ecker and colleagues where medical dispatchers with available video livestream corrected low compressions rate, shallow compression depth, and incorrect hand position in most cases. They corrected only incomplete chest recoil in approximal half of the cases.[15] One reason could be that chest recoil is difficult to evaluate and is not the medical dispatcher's primary focus when guiding the bystanders and could therefore be neglected by the medical dispatcher.

Furthermore, we found that guidance was important for all bystanders and other bystanders took over if the performed CPR seemed insufficient, an aspect that has never been handled in simulation studies. Simulation studies often compare audio-instructed DA-CPR with video-instructed DA-CPR for one bystander from the beginning of the call.[16-20] In a simulation setting, a video-call can be initiated from the beginning, whereas the caller in a real situation always first connects to the dispatcher by traditional audio-call. Therefore, direct comparison of audio-only-DA-CPR versus video-instructed DA-CPR can be difficult on time-related quality parameters in real OHCA. With the use of live video stream, the dispatcher can themselves evaluate bystander CPR directly. During our study period, the medical dispatchers should not initiate CPR with video to avoid delay in first compression but use the video to monitor the CPR performance and guide bystanders if necessary. Live video was an add on to the communication and therefore a comparison between audio-only-DA-CPR and video-instructed DA-CPR was not possible.

In a simulation study, Bolle and colleagues included 180 students, showing a reduction in hands-off time[20] with video-instructed DA-CPR, but they could not show improved hand position, compression rate, or compression depth compared with a normal audio-instructed DA-CPR. On the other hand, they found improved confidence among bystanders when using video for the guidance,[21] and the dispatchers thought video-calls were useful for obtaining information, and CPR assistance became easier.[22] Other simulation studies found improved quality of different measures of the CPR. Yang and colleagues[17] found improved compression rate and depth, whereas both Stipulante and colleagues,[19] and Ecker and colleagues[16] found improved hand position and compression rate. Different positions of the smartphone may facilitate monitoring and feedback on different aspects of CPR quality. A view from above would optimise the assessment of hand position, and horizontal positioning might enhance the ability to evaluate compression depth. According to our protocol (Appendix 1), the smartphone camera should first be placed to optimise the view of the hand position and subsequently repositioned to a horizontal view to evaluate depth and compression rate. However, the medical dispatchers had only been trained with the protocol once and adhering to the protocol seemed difficult in the clinical setting. The bystanders were moving around, and if more bystanders were present, at least one person was placed on each side of the patient, so the view from the video was often somewhat from the side. Hands-off time, which is important for the resuscitation,[23,24] was easily monitored with live video almost independent of camera position. In contrast, rescue breaths were difficult to evaluate. The movement of the chest could be difficult with the video, as Trankler and colleagues found in a simulation setting with a mannequin.[25] However, we found that breathing patterns could be assessed if they were abnormal. The agonal breathing was mainly identified through the opening and closing of the mouth in a pathogenic way by the unconscious patient.

However, live video was only applied by the medical dispatcher in few OHCA cases. Apart from the inclusion criteria with more bystanders present and an available smartphone, we do not know why many medical dispatchers did not suggest live video during the emergency calls. In Seoul, video call was used in 13.4% of OHCA. Caller's age, bystander compliance, ambulance response time, and stress or panic at the location could have influenced the decision. Furthermore, the medical dispatchers might have had barriers to overcome when guiding – for example, If information had to be passed by the caller, the bystander was not receptive to the instructions, or the medical dispatcher stopped guiding because the bystander was a healthcare professional. Our study was not designed to analyse possible barriers for video-instructed DA-CPR.

Today's dispatcher protocol has been designed based on verbal communication. The introduction of video-instructed DA-CPR calls for an adjustment of the dispatcher protocol and for training of the dispatcher in using it. However, the best way to apply this, position of the camera, possible barriers, and when during the call, the video should be added all required further exploration.

Strengths and limitations

The present study analysed the quality of bystander CPR in real OHCA cases using livestreaming from bystander's smartphone. This exploratory study is the first attempt to evaluate this.

The verbal DA-CPR instructions given before video-instructed DA-CPR varied and the CPR quality differed with time, which represents a limitation in our study design. No time interval was chosen for the CPR evaluation since some CPR performance measures were corrected immediately and others later. Due to the explorative design of the study, we decided to measure if CPR was optimised at any given time, which biased the outcome in favour of the "after" group. A pro-innovation bias might be present since the authors did the evaluation, and CPR performance measures were only evaluated visually. Previous simulation studies found approximal 80% agreement between video and manikin with hand position and compressions rate, and 70-80% for compression depth,[15,26] but the assessment might even be easier in a simulation setting. With repeated evaluation through the normal audio communication, the CPR quality might also be improved, which we could not adjust for with our design.

Conclusions

Live video streaming from the scene of a cardiac arrest to medical dispatchers is feasible. It allowed an opportunity for dispatchers to coach those providing CPR which was associated with a subjectively evaluated improvement of bystander's hand position, compression rate, compression depth and arms stretched were improved. Hands-off time was reduced in one-third of cases.

Acknowledgments

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Legends to figures and tables

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Figure 2. The quality for bystander Cardiopulmonary resuscitation before and after Video-instructed dispatcher-assistant cardiopulmonary resuscitation.

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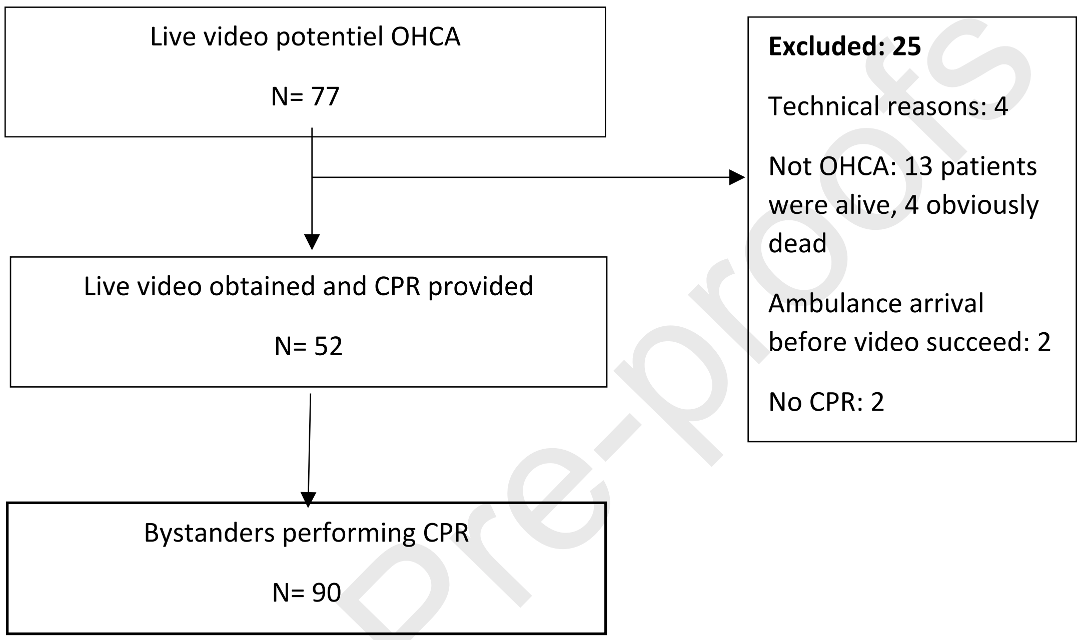
Table 4. The odds ratio for correct or improved cardiopulmonary resuscitation after Video-instructed Dispatcher-assisted cardiopulmonary resuscitation.

Appendix 1. Flowchart for the medical dispatchers about adding live video from bystanders to the emergency call at Copenhagen Emergency Medical Services

Figure 1. Flow diagram of live video transmission from bystander's smartphones to the medical dispatchers in case of cardiac arrest.



CPR=Cardiopulmonary resuscitation, OHCA=Out-of-hospital cardiac arrest

Figure 2. Illustration of the design of the study and how cardiopulmonary resuscitation quality is compared. The "Before video-instructed DA-CPR"- group includes all bystanders performing CPR. Also, bystanders initiating CPR after the video transmission has started, but before the dispatcher instructed.

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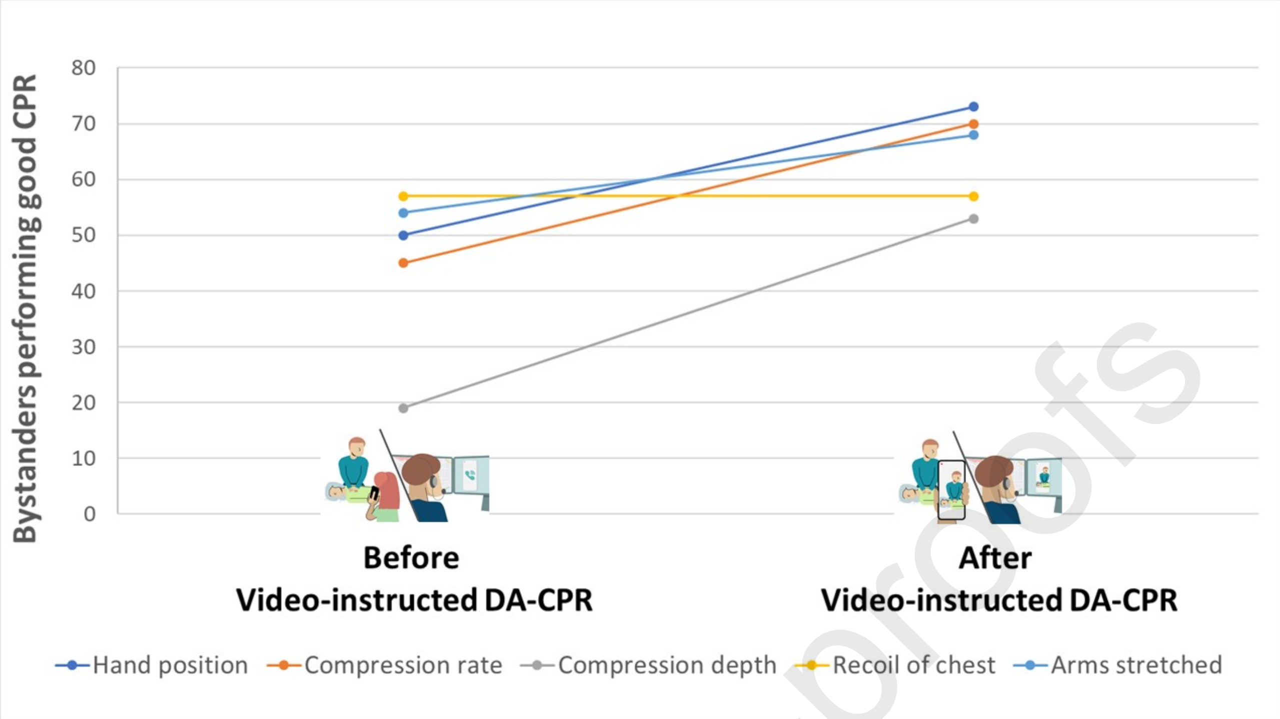

CPR=Cardiopulmonary resuscitation, DA-CPR= Dispatcher-assisted cardiopulmonary resuscitation

Table 1. Description of 52 out-of-hospital cardiac arrest cases where live video was used during the emergency call, and 90 bystanders provided cardiopulmonary resuscitation.

Location	N (%)
Public street	19 (36.5)
Private home	16 (30.7)
Public place indoor	11 (21.2)
Nursing home	6 (11.5)
Etiology	
Medical	48 (92.3)
Traumatic	3 (5.8)
Drowning	1 (1.9)
Witnessed arrest	
Yes	29 (53.9)
Not available	2 (3.9)
Bystanders present	
2–3	20 (38.5)
4–6	26 (50.0)
>7	6 (11.5)
Bystander initiated CPR	
Yes	26 (50)
Bystanders performing CPR	
1	26 (50)

2 3 4	16 (30.7) 8 (15.4) 2 (7.7)
Bystander's sex Female Not available	 40 (44.4) 1 (1.1)
Bystander's age 0–15 years 15–70 years >70 years	 0 90 (100) 0
Bystander's relation to patient Stranger Relative or friend Healthcare/nursing home employee Volunteer citizen first responder Not available	 31 (34) 30 (33.0) 22 (24.2) 4 (4.4) 3 (3.3)
Basic Life Support course Yes Not available	 48 (53.3) 41 (45.5)
Duration of CPR observed on video <1 minute 1–4 minutes > 4 minutes Not available	 30 (33.3) 52 (57.8) 7 (7.8) 1 (1.1)

CPR=Cardiopulmonary resuscitation

Table 2. The quality of cardiopulmonary resuscitation (CPR) before and after the medical dispatchers used video to assist in cardiopulmonary resuscitation (Video-instructed DA-CPR) for 90 bystanders.

The results are divided between the first bystander performing CPR and all bystanders performing CPR afterwards. The CPR quality before Video-instructed DA-CPR is for the first bystanders evaluated as soon as possible from the video. For bystanders performing CPR afterwards the "before score" is the quality of CPR when they begin chest compressions.

All bystanders providing chest compressions, N=90										
	CPR quality before Video-instructed DA-CPR N, (%)			**CPR quality after Video-instructed DA-CPR N, (%)**				**Changed CPR quality after Video-instructed DA-CPR**		
	Correct	**Not Correct**	**NA**	**Correct**	**Not Correct**	**Improved-not correct**	**NA**	**Improved**	**Worsened**	**NA**
Hand position	50 (55.6)	38 (42.2)	2 (2.2)	65 (72.2)	11 (12.2)	8 (8.8)	6 (6.7)	23	0	7
Compression rate	45 (50.0)	36 (40.0)	9 (10)	67 (74.4)	8 (8.9)	3 (faster but still to slow) (3.3)	12 (13.3)	27	1	12
Compression depth	19 (21.1)	57 (63.3)	14 (15.6)	27 (30.0)	23 (25.6)	26 (28.9)	14 (15.6)	33	0	15
Recoil of	57	23	10	55	21	2	12	4	2	13

thorax	(63.3)	(25.6)	(11.1)	(61.1)	(23.3)	(2.2)	(13.3)			
Arms stretched	54 (60.0)	28 (31.1)	8 (8.9)	65 (72.2)	13 (14.4)	3 (3.3)	9 (10.0)	14	0	9
First bystanders providing compressions, N=52										
	CPR quality before Video-instructed DA-CPR N, (%)			**CPR quality after Video-instructed DA-CPR N, (%)**				**Changed CPR quality after Video-instructed DA-CPR**		
	Correct	**Not Correct**	**NA**	**Correct**	**Not Correct**	**Improved-not correct**	**NA**	**Improved**	**Worsened**	**NA**
Hand position	22 (42.3)	29 (58.8)	1 (2.0)	33 (63.5)	9 (17.3)	5 (9.6)	5 (9.6)	17	0	5
Compression rate	25 (48.1)	Slow 13 Fast 8 (40.4)	6	39 (75.0)	Slow 1 Fast 3 (8.7)	1 (faster but still to slow) (1.9)	8 (15.4)	17	1	8
Compression depth	10 (19.2)	31 (59.6)	11 (21.2)	13 (58.9)	11 (21.2)	17 (32.7)	11 (21.2)	19	0	12
Recoil of thorax	33 (63.5)	11 (21.2)	8 (15.4)	32 (61.1)	10 (19.2)	1 (1.9)	9 (17.3)	2	1	10
Arms stretched	33 (63.5)	14 (29.9)	5 (9.6)	38 (73.1)	8 (15.4)	0 (0)	6 (11.5)	5	0	6
Subsequently bystanders providing chest compressions, N=38										
	Correct	**Not Correct**	**NA**	**Correct**	**Not Correct**	**Improved-not correct**	**NA**	**Improved**	**Worsened**	**NA**
Hand position	28 (73.7)	9 (23.7)	1 (2.6)	32 (84.2)	2 (5.3)	3 (7.9)	1 (2.6)	6	2	2
Compression rate	20 (48.1)	Slow 10 Fast 5 (39.5)	3 (faster but still to slow)	28 (73.7)	Slow 1 Fast 3 (10.5)	2 (faster but still to slow)	4 (10.5)	10	0	4
Compression depth	9 (23.7)	26 (68.4)	3 (7.9)	14 (36.8)	12 (31.6)	9 (23.7)	3 (7.9)	14	0	3
Recoil of thorax	24 (63.2)	12 (31.6)	2 (5.3)	23 (60.5)	11 (29.0)	1 (2.6)	3 (7.9)	2	1	3
Arms stretched	21 (55.3)	14 (36.8)	3 (7.9)	27 (71.1)	5 (13.2)	3 (7.9)	3 (7.9)	9	0	2

Table 3. Description of out-of-hospital cardiac arrest cases where the quality of the cardiopulmonary resuscitation was not improved after Video-instructed Dispatcher-assisted cardiopulmonary resuscitation.

	Bystanders	First bystander providing CPR	No Feedback on incorrect CPR, N (%)	Health care professional or nursing home employed N, (%)	Instructions has to pass caller, N (%)	CPR <1 min, N (%)	Patient show sign of live, N (%)	BLS course (yes)*, N (%)
Hand position	11	9 (81.8)	11 (100)	2 (1,1)	2 (20)	5 (45.5)	1 (9.1)	7
Compression rate	8	4 (50.0)	7 (87.5)	2 (25.0)	3 (37.5)	1 (12.5)	0 (0)	6 (75.0)
Compression depth	23	11 (47.8)	18 (78.3)	7 (30.4)	9 (40.9)	8 (34.8)	3 (13.4)	12 (52.1)
Recoil of chest	21	10 (47.6)	21 (100)	5 (23.8)	9 (42.9)	7 (33.3)	3 (13.4)	12 (57.1)
Arms stretched	13	8 (61.5)	13 (100.0)	1 (7.7)	5 (38.5)	7 (53.8)	3 (23.1)	6 (46.2)

*For the remaining bystanders we do not know if they have BLS course.

Table 4. The odds ratio for correct or improved cardiopulmonary resuscitation after Video-instructed Dispatcher-assisted cardiopulmonary resuscitation. Bystanders with missing values were excluded from the analysis.

All bystanders performing chest compressions N=90						
	Unadjusted			**Adjusted**		
	Beta (SE)	**Odds ratio (95%CI)**	**P-value**	**Beta (SE)**	**Odds ratio (95%CI)**	**P-value**
Hand position N= 83	1.9	4.5 (2.5–8.1)	<0.001	2.7	5.8 (2.8–12.1)	<0.001
Compression rate N=78	2.2	6.8 (3.2–14.1)	<0.001	2.5	7.7 (3.4–17.3)	<0.001
Compression depth N=75	0.8	6.7 (3.8–11.7)	<0.001	1.1	7.1 (3.9–12.9)	<0.001
Recoil of chest N=77	1.0	1.1 (0.8–1.5)	0.41	0.2	1.1 (0.8–1.6)	0.41
Arm stretched N=81	1.7	2.6 (1.6–4.2)	<0.001	3.0	2.5 (1.5–4.2)	<0.001
First bystanders performing chest compressions, N=52						
	Unadjusted			**Adjusted**		

	Beta (SE)	Odds ratio (95%CI)	P-value	Beta (SE)	Odds ratio (95%CI)	P-value
Hand position N=47	1.4	5.2 (2.6–10.6)	<0.001	2.5	9.5 (3.4–26.7)	<0.001
Compression rate N=44	2.3	8.3 (2.8–24.7)	<0.001	3.4	12.0 (3.4–17.3)	<0.001
Compression depth N=40	1.0	7.9 (3.6–17.6)	<0.001	0.9	9.2 (3.8–22.5)	<0.001
Recoil of chest N=42	1.2	1.3 (0.7–1.7)	0.41	0.0	1.1 (0.7–1.8)	0.41
Arm stretched N=46	1.6	1.9 (1.1–3.2)	<0.001		2.5 (1.5–4.2)	<0.001
Subsequently bystanders providing chest compressions, N=38						
	Unadjusted			**Adjusted**		
	Beta (SE)	**Odds ratio (95%CI)**	**P-value**	**Beta (SE)**	**Odds ratio (95%CI)**	**P-value**
Hand position N=36	2.8	4.9 (1.4–17.4)	<0.001	3.0	4.2 (1.1–16.4)	<0.001
Compression rate N=34	2.0	5.2 (2.0–13.8)	<0.001	1.6	5.7 (2.3–13.8)	<0.001
Compression depth N=35	0.7	5.5 (2.5–12.1)	<0.001	1.3	5.8 (2.4–13.8)	<0.001
Recoil of chest N=35	0.8	1.1 (0.8–1.8)	0.56	0.6	1.2 (0.7–2.0)	0.56
Arm stretched N=35	1.8	4.0 (1.7–9.3)	0.0013	3.2	2.6 (1.7–13.7)	0.0029

Odds ratios are adjusted for bystander's relation to the patient ("relative/friend", "stranger" or "healthcare/nursing home employees/volunteer citizen first responder") and if the cardiac arrest was witnessed by the bystander.

Conflict of interest

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Author Statement

GL, HC, FL, FF, CM and DØ conceived the study and designed the trial. GL, FL, FF, CM and DØ obtained research funding. GL did data collection. GL, OR and HC analyzed data. AE and HC provided statistical advice on study design and analyzed the data. All authors did interpretation of data. GL drafted the manuscript, and all authors contributed substantially to its revision.