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Improve Survival of Out of Hospital Cardiac Arrest with Video-directed Chest Compressions

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Abstract

Background: Cardiovascular disease has been the leading cause of mortality worldwide for the past century, but advancements in health intervention have led to a decline of over 20%.

However, the Out of Hospital Cardiac Arrest (OHCA) mortality rate remains unacceptably high, exceeding 90% over the past few decades. The primary reasons are the lack of cardiopulmonary resuscitation (CPR) knowledge and delayed medical response [1]. In 2018, the American Heart Association (AHA) introduced audio-directed CPR by 911 operators. However, the effectiveness of this approach in guiding laypeople to perform CPR is far from optimal [2].

Methods: Laypeople were randomly divided into audio and video groups, with each group receiving instructions through their respective medium on how to perform CPR on manikins. Simulated OHCA scenarios were created, involving on-site testing with subjects having no prior CPR experience, and a remote call site providing CPR instructions either through audio or video. Both on-site and online activities were recorded and analyzed. The accuracy of hand positions, the time of CPR initiation, the speed and effectiveness (depth) of chest compressions were tracked and compared between the audio and video guided groups based on AHA requirements.

Results: Across 61 trials, CPR initiation occurred in 22 ± 11 seconds in the audio group and 22 ± 6 seconds in the video group. Hand location accuracy was 77% in audio participants and 97% in video participants ($p<0.05$). The average speed of CPR was 0.55 ± 0.23 seconds with audio guidance and 0.45 ± 0.27 seconds with video guidance. The effectiveness of compressions was 33% ± 39% in the audio group and significantly improved to 79% ± 26% in the video group ($p<0.0001$).

Conclusion: The implementation of a new video-guided CPR system can significantly enhance CPR effectiveness when compared to the audio-assisted approach.

Keywords: CPR, Chest compressions, Manikins, Audio-guided, Video-guided, Out-of-hospital cardiac arrest

Abbreviations: AEDs: Automated External Defibrillators; AHA: American Heart Association; ALS: Advanced Life Support; BLS: Basic Life Support; CPR: Cardiopulmonary Resuscitation; EMTs: Emergency Medical Technicians; OHCA: Out-of-Hospital Cardiac Arrest

Introduction

The provision of adequate care for patients experiencing cardiac arrests outside of the hospital continues to present numerous challenges in the current healthcare landscape. Out of hospital cardiac arrests (OHCA) occur with varying frequencies in different settings, including 70% in homes or residences, 18.8% in public settings, and 11.2% in nursing homes [3]. Although advancements have been made in the emergency response system, transitioning from a passive approach of waiting for the ambulance to a proactive strategy of 911 call-directed CPR, the fatality rate of OHCA remains high, with approximately 90% of cases resulting in death. Current data on CPR performance reveals that only 46% of

OHCA patients receive CPR, as reported by the 2017 American Heart Association (AHA) data [4]. Furthermore, a recent survey conducted by the Cleveland Clinic in 2021 indicated that 54% of Americans claim they know how to perform CPR. However, only one in six know that it is recommended for bystander CPR on an adult to consist of only chest compressions and no breaths. Even fewer, 11 percent, are knowledgeable of the AHA guideline of proper pacing (100 to 120 beats per minute) [5]. These statistics highlight the urgent need for a new system that can enhance access to first aid, given that immediate CPR can significantly increase the chances of survival for OHCA patients.

The importance of immediate first aid becomes evident when considering the average response times of Emergency Medical Technicians (EMTs), which stand at 7 minutes for urban areas, 14 minutes for rural areas, and, alarmingly, over 30 minutes for more than 10% of emergency cases [6]. In light of this delay, a novel approach is required to ensure prompt and effective assistance. Specifically, there is a dearth of research examining the efficacy of video guidance in enhancing CPR performance, particularly regarding various critical aspects of performing proper compressions, such as accurate hand positioning, prompt initiation of CPR, and adequate speed and depth of chest compressions. To address this gap, a proposed system would provide family members with valuable support during times of distress by offering visual demonstrations of CPR procedures and real-time feedback on the effectiveness of chest compressions through a video interface. If widely adopted and implemented on a large scale, this innovative approach has the potential to revolutionize OHCA outcomes and significantly improve CPR performance.

Materials & Methods

Participants selection

The study aimed to recruit a diverse group of volunteers without prior CPR experience to investigate the effectiveness of a new video-guided 911 call system in assisting the majority of US citizens who lack CPR knowledge. The participants were randomly assigned to either the audio or video group, which determined the type of guidance they received for performing CPR on manikins. An emphasis was placed on achieving a wide range of age and gender among the participants to assess the applicability of the newly-introduced 911 video system across different demographics.

Audio calls setup

BLS certified instructors oversaw the study and assumed the role of simulated dispatchers during the experiment. All participants, acting as caretakers or lay people attending to the victim, engaged in a cardiac arrest simulation, and were instructed to perform CPR on a manikin representing the victim. The volunteers were randomly assigned to this group and phone-called the instructors, similar to the current 911 call setup. The dispatchers read out instructions and assessed the participants' progress in performing CPR.

To ensure consistent instructions, an off-site call center provided guidance to the on-site testing subjects. Using manikins allowed for standardized and controlled conditions during the simulations, minimizing potential variability and biases.

Video calls setup

Similar to the audio calls study, all subjects and "dispatchers" participated in a simulated cardiac arrest scenario as described above. The "dispatcher" sent a Zoom link to the participant, ensuring proper visibility of the volunteer by verifying that the caregiver had the phone properly positioned or held by another person. Both the participant and the individual giving instructions could hear each other clearly, aided by a stable wireless network connection.

Audio calls instructions

Dispatchers followed the standard CPR instructions for adults outlined in the Emergency Medical Dispatch GuideCards, specifically Part I2 sections A, B, and D, in sequential order.

Instructions in sections B and D pertaining to mouth-to-mouth breathing were excluded, as untrained bystanders are now advised to focus on delivering effective chest compressions instead [7].

Video calls instructions

Dispatchers followed the standard CPR instructions for adults outlined in the Emergency Medical Dispatch GuideCards, specifically Part I2 sections A, B, and D, in sequential order. Mouth-to-mouth instructions were also excluded from sections B and D. Subsequently, the dispatcher visually verified that the caregiver was appropriately positioned beside the patient, with the patient's chest exposed, and that the caregiver's hands were correctly placed on the chest. The dispatcher then performed 30 compressions on a manikin simultaneously with the caregiver's compressions on the patient. Based on the caregiver's performance, the dispatcher provided guidance on increasing the speed or intensity of the compressions, along with any other necessary instructions, to ensure effective compressions aligned with AHA guidelines (100-120 compressions per minute and a depth of 1 ½ to 2 inches).

Statistical analysis

CPR compressions performed by both the audio and video groups were recorded for subsequent analysis. The effectiveness of their performance was evaluated based on the following categories: time of initiation, hand placement, and frequency and depth of compressions. CPR initiation measures the time taken to initiate compressions. Hand placement assessed whether the heel of the hand was positioned correctly at the center of the chest. Frequency referred to the duration required to complete 30 compressions. The effectiveness of compressions was determined by the manikin's monitor light, where a green light indicated that the candidate met the AHA guidelines for compression depth (at least 1 ½ inches), while a red or yellow light indicated a failure to meet the depth requirement. The chart below records effectiveness of compressions in the column depth, indicating how many of the participant's total compressions led to a green light on the manikin. All categories were statistically analyzed using a two-tailed paired t-test in the Jump program to determine if there were significant differences in performance between the two groups.

Results

Audio

Table 1: 30 audio trials were conducted. Each participant's age, gender, and CPR experience were recorded to see if these impact their performance of chest compressions. Different criteria of CPR compressions (initiation, location, frequency, depth) were used to analyze the effectiveness of participants' compressions.

Initiation (seconds)	Location (yes- centered; no- not centered)	Frequency (30X- sec)	Depth (lights on)	Age	Gender	CPR experience
30	no	23	0/39	39	F	yes
24	yes	11	24/30	31	M	no
31	yes	13	0/80	43	F	no
16	yes	20	9/24	40	F	no
26	yes	15	39/47	41	F	no
16	yes	12	0/38	44	F	yes
35	no	13	0/92	44	F	no
35	yes	14	73/73	21	M	no
27	yes	12	0/65	37	F	yes
43	yes	30	8/47	49	M	no
17	yes	14	27/34	17	M	no
26	yes	15	0/44	47	F	no
29	no	21	0/42	47	F	no
61	yes	47	0/40	71	F	no
15	no	15	0/30	59	F	yes
14	no	14	8/30	39	F	no
14	no	15	0/28	35	F	yes
22	yes	22	25/32	15	M	somewhat
15	yes	15	0/30	15	F	somewhat
15	yes	16	26/26	16	F	yes
10	yes	12	0/25	17	F	no
13	yes	13	31/31	17	F	yes
15	yes	15	22/30	16	F	yes
15	yes	15	13/30	17	M	yes
15	yes	15	0/30	28	F	no
12	yes	12	N/A	33	M	yes
19	no	13	0/43	17	M	no
18	yes	13	26/43	17	F	no

23	yes	18	0/37	33	M	no
12	no	14	7/30	17	F	yes

Video

Table 2: 31 video trials were conducted. Each participant's age, gender, and CPR experience were recorded to see if these impact their performance of chest compressions. Different criteria of CPR compressions (initiation, location, frequency, depth) were used to analyze the effectiveness of participants' compressions.

Initiation (call-start time)	**Location (yes- centered; no- not centered)**	**Frequency (30X-sec)**	**Depth (lights on)**	**Age**	**Gender**	**CPR experience**
20	yes	12	43/50	19	M	no
39	yes	13	93/97	50	M	no
35	yes	16	56/71	20	F	no
23	yes	14	50/52	32	F	no
16	yes	12	35/36	43	M	no
16	yes	13	38/39	17	F	no
16	yes	12	40/40	17	M	yes
12	yes	12	30/30	16	F	yes
19	yes	19	10/39	17	F	yes
28	yes	15	44/54	17	M	no
14	no	13	16/32	17	F	no
21	yes	19	32/34	55	F	no
22	yes	17	34/39	16	F	no
21	yes	10	47/52	44	F	yes
23	yes	12	24/57	16	M	no
29	yes	13	58/65	17	F	yes
28	yes	13	43/67	18	F	no
28	yes	14	36/50	13	F	no
27	yes	12	52/52	30	M	no
22	yes	13	49/50	35	F	no
29	yes	14	47/62	52	F	no
21	yes	13	47/50	15	M	no
26	yes	13	48/58	17	F	no
14	yes	14	26/30	17	F	yes
18	yes	14	33/37	17	F	no
15	yes	13	31/32	14	M	no
18	yes	12	47/47	18	M	no
24	yes	11	57/63	14	M	no
34	yes	14	48/78	51	M	no
21	yes	17	6/37	17	M	no
21	yes	12	0/44	18	F	no

Statistical analysis (2 tailed paired T-Test)

Table 3. Compares the effectiveness of compressions between audio and video groups. Audio-guided participants performed significantly worse.

	CPR start (sec)	Hand location	Speed CPR (sec)	Effectiveness
Audio n=30	22±11	77%	0.55±0.23	33%±39%
Video n=31	22±6	97%*	0.45±0.27	79%±26%**

* p<0.05 and ** p<0.0001

Discussion

The hypothesis proposed in this study is strongly supported by the results obtained from the 30 audio and 31 video trials conducted. The two-tailed paired t-test revealed significant improvements in all aspects of CPR performance for participants in the video-guided group.

Although CPR initiation time remained consistent between both groups, the video-guided participants exhibited a slightly narrower margin of error. Notably, the accuracy of hand placement on the center of the chest significantly increased by up to 20% for the video-guided group compared to the audio-guided group (p<0.05). Furthermore, the speed of CPR improved by 0.10 seconds in the video-guided group. Most importantly, the depth or effectiveness of compressions demonstrated a remarkable 44% increase in the video-guided category (p<0.0001).

While the results strongly advocate for the implementation of a video-guided emergency support system, a noticeable trend emerged regarding the individuals who provided the most effective compressions: young males. In contrast, older females tended to struggle in meeting the AHA requirements of 100-120 compressions per minute and a depth of 1 ½ to 2 inches. This discrepancy may be attributed to the better physical fitness and athletic instincts exhibited by younger males, resulting in more natural and consistent pacing. Even with only verbal instructions in the audio-guided group, younger males, and males in general, outperformed their female counterparts. This finding is supported by the fact that out of the 15 audio participants who failed to perform any effective compressions, 13 were females.

Analyzing the two charts presented above, significant differences between the performances of audio-guided and video-guided participants can be observed. The time of initiation, measured from the start of instructions to the beginning of compressions, increased by 0.10 seconds in the video-guided group, as mentioned earlier. However, there was also a narrower range of time of initiation, with a difference of 51 seconds between the longest and shortest commencements in the audio-guided group, compared to 27 seconds in the video-guided group. This study reinforces the notion that a novel video emergency system can ensure better control of outcomes and result stability. The majority of participants in both categories demonstrated accurate hand placement, as explained in detail by Emergency Medical Dispatch GuideCards Part I2 Section D: “Put the heel of your hand on the center of the chest, right between the nipples. Put your other hand on top of that hand. Push down on the heels of your hands, 1 ½ to 2 inches” [8]. However, the presence of BLS instructors performing thirty compressions along with the participants in the video-guided group provided a visual example for those who had never performed CPR before, resulting in only one participant demonstrating inaccurate hand placement in the video-guided group, compared to eight in the audio-guided group. Furthermore, the visual demonstration led participants to mimic the instructors’ pacing, resulting in an average speed of 13.581 seconds for CPR in the video-guided group and 16.567 seconds in the audio-guided group. The improved pacing among the video-guided participants can also be attributed to the ability of the dispatchers to directly observe the caregiver’s compressions and provide instructions to slow down or speed up when necessary.

To minimize potential biases, the manikins were positioned in a way that participants could not directly view the monitor light. Placing their chests directly above the manikin’s position would cover the blinking monitor light, which provides feedback on the effectiveness of compressions. This study aimed to determine if a new approach to emergency response could assist individuals without CPR experience, thereby eliminating the possibility of participants adjusting the quality of their compressions based on the monitor light as this is not possible for treating victims in real-life situations.

Real world implications

According to the AHA journal, OHCA survival cases have identified key components for survival, including prompt recognition of cardiac arrest, use of automated external defibrillators (AEDs), effective bystander CPR, and activation of professional basic life support (BLS), with emphasis on professional basic life support (BLS) over additional advanced life support (ALS) services. However, numerous crucial factors affecting patient survival remain unmeasured due to the absence of video evidence for cardiac arrest analysis. This encompasses the time from collapse to witness recognition and the interval from bystander recognition to intervention. To address this, a video-guided emergency system is proposed as demonstrated by a study conducted in Valenzuela casinos. This study established a 60% survival rate when patients experienced syncope and received prompt treatment within three minutes, exhibited ventricular fibrillation, and were promptly defibrillated based on video-recorded data (analysis possible due to presence of video recordings). Despite these findings, many of these critical survival components are not consistently enacted. For instance, the unfortunate death of professional basketball player Zeke Upshaw even among thousands of spectators highlights the critical importance of timely CPR and AED application in preventing fatal outcomes [9].

In 2017, the Seoul dispatch center introduced a video-call system as a supplement to the existing audio-call system. While limited clinical studies have been conducted thus far, concerns regarding technology reliability and WiFi availability in remote areas suggest that a coexistence of video and audio systems, rather than a sole reliance on video 911 calls, would be more practical. Nonetheless, ongoing real-life studies are progressively paving the way for the integration of video-guided CPR support. The Seoul Emergency Operation Center (SEOC) adopted the video system in real-life involving multiple bystanders with access to reliable internet, resulting in 387 patients receiving video-instructed CPR [10].

The feasibility of a video-guided CPR network is influenced by WiFi accessibility, yet potential barriers can be overcome. Raising public awareness about video-instructed CPR can foster acceptance and willingness to embrace this novel approach [11]. Furthermore, the ubiquity of cellphones, with 91% of Americans owning one, facilitates the transition from audio to video calls [12]. Although remote areas may still rely on traditional audio 911 calls, studies demonstrate improved CPR quality with the video-based procedure.

Patients instructed through video are strongly associated with enhanced neurological outcomes (n=75, 19.4%) compared to audio-guided cases (n=117, 6.8%). Additionally, survival rates at discharge significantly increased from 12.3% in the audio group (n=211) to 27.1% in the video group (n=105) [11]. While some studies report heightened chest compression rates with video guidance, the timing of the first compression did not exhibit significant improvement [13].

Contrary to concerns of potential delay, following video instructions did not significantly affect the initiation time, as evidenced by consistent results across various discussions.

This study's methodology differs, as the instructor determined the start of 30 compressions, eliminating emotional factors and hesitancy. This approach distinguishes it from studies involving only bystanders performing compressions and highlights the video system's value in assessing compression efficacy and offering visual guidance for laypersons to alleviate anxiety and hesitation. The study supports the applicability of the video-guided approach for both CPR-experienced and inexperienced participants.

In addition to enhancing technical CPR performance, a video-guided emergency system offers emotional support to bystanders and victims' families, potentially expediting assistance by reducing pauses in chest compressions. Dispatchers can evaluate bystanders' fatigue and emotional states, directing alternate individuals to perform CPR when more than two witnesses are present. This approach is most effective when one bystander aids the primary compressor by managing the camera angle.

Considering the rising incidence of OHCA due to aging populations and increased cardiovascular diseases, an urgent need exists for implementing a video emergency system alongside audio 911 calls. Failing to adopt new strategies could perpetuate the upward OHCA trend. As reported, the incidence rate rose from 37.5 per 100,000 in 2006 to 46.8 per 100,000 in 2010 [11]. Addressing this challenge requires larger population studies and collaboration with local fire departments to operationalize the proposed system. This encompasses the establishment of an official video emergency platform (e.g., Zoom, FaceTime) and conducting community-based trials. Achieving this necessitates cooperation with health departments to ensure legal and effective implementation.

Limitations & Conclusion

Limitations

This study, comprising 61 trials, has several limitations that should be acknowledged. Firstly, the participants were randomly divided into two groups, video and audio, which may introduce potential selection bias. Additionally, the study focused on a simulation setting, and the results may not fully reflect real-life emergency situations. It is essential to conduct further research to explore the effectiveness of video guidance in a broader context and encompass a more comprehensive assessment of CPR procedures. Lastly, the study's sample size was limited, and a larger-scale study involving a diverse population is necessary to ensure the generalizability of the findings.

Conclusion

The findings of this study strongly support the adoption of a video-guided emergency system for CPR instruction. The video-guided participants demonstrated superior performance in all assessed criteria, including time of initiation, hand location, and depth and frequency of compressions. The implementation of a video call system enables dispatchers to provide live demonstrations of CPR and offer immediate feedback, leading to improved compression quality among laypeople. While challenges exist, such as limited cell signal in rural areas, this calls for the coexistence of audio and video emergency systems as it has the potential to revolutionize Out-of-hospital cardiac arrest rates, particularly in urban settings where the study revealed difficulties in rectifying compression errors solely through audio calls. Further development of this system, including execution refinement and clinical trials to assess real-life impacts, is essential. By addressing the limitations outlined above and conducting large-scale studies, we can advance the development and implementation of video-guided emergency systems to enhance CPR performance and ultimately save more lives in emergency situations.

Conflicts of Interest

The authors listed on this paper have no affiliations with any organization with financial interest or non-financial interest in the subject discussed in this manuscript.

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