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A Local Neighborhood Volunteer Network Improves Response Times for Simulated Cardiac Arrest.

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Abstract

Aim: Each minute is crucial in the treatment of out-of-hospital cardiac arrest (CA). Immediate chest compressions and early defibrillation are keys to good outcomes. We hypothesized that a coordinated effort of alerting trained local neighborhood volunteers (vols) simultaneously with 911 activation of professional EMS providers would result in substantial decreases in call-to-arrival times, leading to earlier CPR and defibrillation.

Methods: We developed a program of simultaneously alerting CPR- and AED-trained neighborhood vols and the local EMS system for CA events in a retirement residential neighborhood in Southern Arizona, encompassing approximately 440 homes. The closest EMS station is 3.3 miles from this neighborhood. Within this neighborhood, 15 vols and the closest EMS station were involved in multiple days of mock CA notifications and responses.

Results: The two groups differed significantly in distance to the mock CA event and in response times. The volunteers averaged 0.3±0.2 miles from the mock CA incidences while the closest EMS station averaged 3.4±0.1 miles away ($p<0.0001$). Response times (time from call to arrival) also differed. Two volunteers, one bringing an AED, averaged 1 min 38 sec ± 53 sec in Phase 1, while it took the EMS service an average of 7 min 20 sec ± 1 min 13 sec to arrive on scene; $p<0.0001$.

Conclusion: Local neighborhood volunteers were geographically closer and arrived significantly sooner at the mock CA scene than did the EMS service. The approximate time savings from call to arrival with the volunteers was 4-6 minutes. [243 words]

Key Words: out-of-hospital cardiac arrest, neighborhood volunteer response network, EMS services, Chain-of-Survival, crowdsourcing, and digital-mobile device technology

Introduction

The key to improving survival from out-of-hospital cardiac arrest (CA) is the "Chain of Survival".[1] Experience over the last two decades has shown that, though all links can influence survival, the first three, i.e. early recognition of the problem, early CPR, and early defibrillation for those with shockable rhythms, are the most potent targets for improving long-term, neurologically favorable outcomes.[2] There are numerous reports showing that early CPR can increase survival from out-of-hospital CA.[3-11] Bystander CPR, when begun immediately upon the victim's collapse, can raise the CA survival rate 2- to 3-fold.[7-11] The power of bystander CPR to increase survival is well recognized but rates of bystander assistance ,unfortunately, remain low, with the national average about 40%.[12]

Historically, efforts to increase bystander involvement in the early treatment of CA victims have included major campaigns to educate the lay public about this national public health crisis, and to train them to provide basic life-supporting skills until the arrival of professional EMS providers. In a few communities this approach has been quite successful,[12] but less so in most others. Cardiac arrests occurring in public places have better outcomes than those occurring in homes or residences.[8,13] Contemporary studies have found higher rates of initially shockable rhythms among CA occurring in public places than in non-public areas, with better survival after CA in public areas than in the privacy of one's own home.[14] Our historical efforts at public programs to enhance bystander CPR participation have only been partially effective because they have not penetrated the residential communities as much as the workplace or other general public venues. Unfortunately, the most common location for CA is in the non-public arena, typically at home. More than 70% of out-of-hospital CA occurs in private residences.[13,14] Finding a solution to help this majority receive timely bystander CPR is critical and requires new, innovative approaches.[15-24]

A promising approach is local, neighborhood-based volunteer networks for responding to mobile-phone alerts of CA within their own communities. This concept was first suggested in 2001 as a "neighborhood health watch program: Save A Victim Everywhere (SAVE)",[25] but to date has not been extensively tested[26]. We hypothesized that local neighborhood volunteer networks responding to cardiac arrest emergencies in their own residential communities would provide earlier CPR and more bystander AED use than communities dependent solely on professional EMS providers. Such earlier treatment of cardiac arrest should result in increased survival rates. Here we detail results of a pilot study of local neighborhood-based volunteer networks for responding to mobile-phone alerts of simulated community CA events.

Methods

Study Design

This study was a prospective, observation comparison of a local neighborhood volunteer network versus professional EMS providers' response times from call to arrival for mock out-of-hospital CA events. The primary endpoint was time from call to arrival at residential address of the mock CA. University of Arizona Institutional Review

Board approval was obtained for this study. All volunteer data were de-identified and reported only as a group, not per individual.

Study Setting

The study was performed in a well-defined, age 55 and older, active adult community located in Green Valley, Arizona. The Springs at Santa Rita ("The Springs") consists of 442 homes developed between 1996 and 2003. Green Valley has five fire stations, all of which respond to 911 calls for emergency services. The closest station to The Springs residential development is approximately 3.3 miles away. The study was performed in two phases, the first during May 2018 and the second in August 2018. Phase 1, evaluated whether volunteers could arrive faster than the professionals. We decided to run additional trials over a two week period of time, during the summer, and at different hours of the day (8 am to 7 pm). This Phase 2 was done to ensure that our results were also valid over different seasons of the year, different days within the week (including weekends), and different hours of the day. In Phase 2, we also reduced the number of available AED locations from six to one based on response times in Phase 1, which had shown that reducing the location of the AED to one from six had no impact on elapsed time of neighborhood volunteers' arrival in this community of 442 households. Phase 2 also required volunteers to enter the home, begin CPR on a manikin, and connect the AED to the patient's chest.

Study Population

This study consisted of a group of neighborhood volunteers from The Springs and the closest fire station staffed with professional firefighter EMS first responders. The original volunteer group consisted of 9 volunteers, 5 women and 4 men. A second group of volunteers was added later, consisting of an additional 4 volunteers, 1 woman and 3 men, bring the total to 13 volunteers.

Study Protocol

The idea of local neighborhood volunteer networks responding to CA emergencies in their own residential areas, and the rationale for such a program, was presented to the Green Valley Council of Homeowners Associations (HOA). Understanding that minutes are crucial in the treatment of out-of-hospital CA and that immediate chest compressions and early defibrillation are keys to good outcomes, they agreed to pilot a local neighborhood volunteer response program designed to decrease delays to early CPR and AED use in residential areas. We hypothesized that a coordinated effort of alerting trained neighborhood volunteers simultaneously with 911 activation of professional EMS providers would provide earlier CPR and defibrillation in such communities. The Council was very interested in participating and assisted us in identifying a community in which to conduct the study and to find a good number of volunteers. In conjunction with an enthusiastic HOA, we approached the Green Valley Fire Department to discuss the concept of local neighborhood volunteers willing to be trained in CPR and AED use. They would be notified for CA events simultaneously with the EMS providers, with both expected to respond to the emergency. The Fire Department was also willing to explore this concept, and agreed to participate in both planning and conducting a series of mock CA events to test response times of such

neighborhood volunteers and the closest professional EMS/Fire Fighter station. After some discussion and responding to their concerns and questions, the leadership of Green Valley Fire agreed to participate and felt such a program could benefit their community. A plan was developed for a series of "mock" CA calls and measurement of response times for both neighborhood volunteers and EMS providers. A neighborhood residential community was chosen and an adequate number of willing volunteers were recruited. A volunteer training program was scheduled to teach them chest compression-only CPR and how to operate an AED.

All five fire stations in Green Valley respond to 911 calls for emergency services. The closest station to The Springs residential development was selected to respond to our "mock" CA upon receipt of a call regarding a potential CA. It was agreed that any true emergency would take precedence over responding to any mock events. The distance to the mock event and the time from alert to arrival were recorded for both volunteers and the EMS providers. Times to the minute were recorded when the alerts were broadcast via text message to the volunteers and via cell phone call to the fire station. Times to the minute were recorded in Phase 1 for the arrival of each volunteer and the fire department response vehicle at the trial address. In Phase 2, times to the minute were recorded for the arrival of each volunteer inside the mock victim's residential dwelling. The time of the initiation of CPR on the manikin was noted to the minute, as was the application of the AED to the manikin. The time was recorded by a member of the field work team (TC), who was aware of the study hypothesis. The Fire Chief verified arrival times of the fire department teams and each volunteer also submitted a time slip upon arrival. Comparisons were made between volunteers and professional EMS providers.

Dispatch System

For this study, volunteers were notified via text message and EMS was notified simultaneously by a direct voice call to the participating station by the Fire Chief.

Mock Cardiac Arrest Events

The mock trials took place during the months of May (Phase 1) and August (Phase 2) in 2018. Mock testing during Phase 1 (9 volunteers) was held on three days (Monday, Tuesday and Wednesday), with four alerts per day between the hours of 8 am to 4 pm (total of 12 different alerts at various times during daytime hours). This provided a total of 120 response opportunities, 12 for EMS and 108 for volunteers.

Additional mock testing (Phase 2) expanded the 9 volunteers to 13 (7 men, 6 women). Weekends were now included in the random testing window and the hours expanded to 8 am to 6 pm. Summer was deliberately chosen for this 2nd phase of mock testing, a season when many Southern Arizonans travel to escape the summer heat. The Fire Department was not included in this series of tests, since their distance and responses were well-documented in Phase 1. Four different mock CAs were staged, including one on a rainy Saturday afternoon. During Phase 2, between 10 to 12 volunteers participated since some of the 13 were out-of-town during the testing period. Mock events occurred on Monday, Tuesday, Thursday and Saturday between the hours

of 8 am to 6 pm over a two-week period in various weather conditions. Only one test per day was done during Phase 2, but the days were spread out over a two-week window. Phase 2 provided a total of 46 volunteer response opportunities.

When the simulated emergency calls were made, the professionals responded as if the calls were real. The nine-member group of resident volunteers was also instructed to respond. Each volunteer received a text message with directions to a certain address for each trial. Some were assigned to pick up an AED (defibrillator) at one of the designated spots within the community center. The others went directly to the home. Volunteers were advised to go about their normal business and not be waiting for the messages; otherwise, the study would be less realistic.

Various home locations were chosen as the site of the simulated CA emergency. Figure 1 highlights the location of these different sites. The Springs was an ideal community in which to conduct this first pilot study since this neighborhood is the farthest from an assigned fire station in Green Valley.

Data Collection

Characteristics and Results of Mock Events

Data collection included: 1) date (month of the year, day of the week); 2) time of the day; 3) general weather on day of the mock event 4) distances from closest EMS station and all neighborhood responders; 5) time from alert until arrival at the scene. Such data was gathered for each class of responder, both volunteers and EMS professionals.

Data Analysis

Characteristics of the volunteers participating in the study were summarized by frequency and the associated percentage for each of the categorical characteristics (e.g. sex) and by mean and the associated standard deviation for each of the continuous characteristics (e.g. age), respectively. Fisher's exact test and two-sample t test was performed to compare categorical and continuous characteristics, respectively, between the volunteers and EMS professionals.

For each mock event, the mean and associated standard deviation was reported for distance traveled and call-to-time of arrival. Two-sample t testing was performed to compare distances and times between the volunteers and EMS professionals. All statistical tests were 2-sided, with p values ≤ 0.05 considered to indicate statistical significance.

Results

Data on the community of Green Valley and "The Springs" neighborhood demographics and characteristics are displayed in Table 1. Additional data was gathered on all volunteers to characterize this group and their prior experience with CA and emergency responses (Table 2). Of note, male/female participation was nearly

equal. The average age was 70 years. All were retired, though two were working part-time again. Five of 12 were former medical professionals, including an RN, a family physician, a dentist, a medical social worker, and a military veteran with medical training.

Distances to travel to the mock CA events were significantly less for neighborhood volunteers compared to the EMS providers stationed at the closest Fire Station. Volunteers arrived at the scene by car, golf cart or bicycle. One arrived in pajamas. The volunteers averaged 0.33±0.2 miles from the mock CA incidences while the closest EMS station was 3.4±0.1 miles from the tested neighborhood ($p<0.0001$).

The primary endpoint of time from alert to arrival at the residential address was significantly shorter for the neighborhood volunteers (Table 3). The average time difference for arrival of for 2 volunteers with an AED versus the team of professional EMS providers was 5 minutes 42 seconds.

At least three volunteers responded to all scenarios, but not all volunteers responded to every alert. In Phase 1, 32% (35/108) of the volunteer alerts did not result in a response by the alerted individual. Volunteers noted that they did not respond for a variety of reasons. One forgot her cell phone was "off", one was playing tennis, several were indisposed, and some were simply unavailable for other reasons. An average of 5.8±1.2 (range 3-7) volunteers arrived at each scene. Emergency medical services was unable to respond to 3 of the 12 (33%) mock events due to other real-life emergencies. In such cases in real emergencies, the next closest station (4.8 miles) would respond for true emergencies but, being further away, such a secondary response would take even longer to arrive, probably 9-10 minutes.

As anticipated, the volunteer response rate was lower with 29/49 (59%) volunteer alerts not resulting in a response during the week in August. Again, never did less than 3 volunteers arrive at the mock scene to assist. In every case, a volunteer arrived with the community AED. Average distance traveled for volunteers in this testing period was 0.3 ± 0.1 miles. Table 3 compares the Phase 1 & 2 response times. Arrival time for 2 volunteers and an AED was longer by 2 min 8 sec, which was a significant difference ($p<0.001$). Note that the response times in Phase 2 trials were measured based on entering the home of the mock event and beginning CPR on a manikin, adding some time to the results as expected. The response times for the professional teams would also have increased slightly using the same protocol.

Discussion

This initial experience suggests that a network of local neighborhood volunteers, geographically closer to the mock CA event, arrive significantly sooner at the scene than the EMS service. The mean time of arrival for at least 2 volunteers with an AED was 4 to 6 minutes faster than the professional rescuers. Pollock et al., using out-of-hospital public area cardiac arrest data, showed that such a time saving between bystander defibrillation using an AED versus AED defibrillation by the EMS professionals would equate to a doubling of the survival rate with good neurological function from 35% to 70%.[27] Cardiac

arrests occurring in residential homes may be different, including less shockable rhythms, than those occurring in the public sector. However, the benefit of early CPR for residential cardiac arrests could still be substantial.[28]

The firefighter EMTs traveled an average of .43 miles per minute in responding to the mock events. The neighborhood volunteers traveled only about half that speed (.24 miles per minute) but obviously were always traveling much shorter distances on neighborhood streets. These data suggest that, if the closest fire/EMT station is further than 1.29 miles from the site of the CA, the neighborhood volunteers should be able to arrive before the professional responders. Even if the station is within this calculated distance, neighborhood volunteer responders may have value just in case the EMTs have conflicting priorities that delay their arrival (e.g. by pushing the response to a more distant station). In this regard, the next closest station for "The Springs" neighborhood is 4.8 miles distance away. This is 25% further than the closest station. An additional 25% time from call to arrival for the professional providers would translate into an expected time of arrival time of 9 min 10 sec. The difference then could be as high as 8 min 28 sec sooner for the local neighborhood responders.

The local neighborhood volunteers from The Springs had positive experiences and felt good about their involvement. Some of their comments included:

- "This could definitely save some lives. We're very happy to be a part of it [the study]."—*Chief Operating Officer, Green Valley Recreation, Inc.*
- "Participating in the study made me realize that we can make a difference and save lives here in our community. We had no trouble finding enough volunteers."—*a volunteer and former HOA board member*
- "With the training we received and getting notice of an emergency I am confident that I could save a life if the need arose." ."—*a volunteer*
- "I see this as the right thing to do and came away from the training energized with the knowledge that I could save a life." ."—*a volunteer*

The use of wireless capabilities is increasingly being used in emergency situations. One such smart phone application dedicated to sudden cardiac arrest is PulsePoint (29**)**. The key difference between the system modeled in our study and PulsePoint is that the latter focuses on sudden cardiac arrests that occur in public, high density locations such as city centers, shopping malls, and sports arenas. By design, PulsePoint is not typically being used in suburban residential neighborhoods.

A number of practical lessons were learned from this pilot project. The alert system had some issues. Once the alert misspelled the street address of the mock emergency. The map function failed to work during another alert. Occasionally, volunteers complained they could not hear the alert while they were engaged in other tasks. Such issues are remediable and were successfully dealt with during this pilot study. The community leadership had questions at the end of the pilot study about how to best continue a program of ongoing community education and volunteer training, and what was the best number of volunteers to keep the program functional. The answer to such questions are not yet

known. We were able to demonstrate that a single central AED location was sufficient; no significant differences were noted compared to having as many as six AEDs located throughout the selected community.

Limitations

This was a simulation study and it can only estimate the effect of such early access to CPR and AED use for victims of residential CA. We realize such estimates are based on the "best possible circumstances" and may overestimate the actual time savings. However, the time saving was not small, but rather 4-6 minutes in this simulation. Even if it were only half that in real world situations, a substantial benefit could be achieved. It will be imperative to collect relevant data for real cardiac arrest events, including when emergency calls are placed, how long it takes the 911 center to determine the nature of the emergency and dispatch alerts to responders, the time to arrival, initiation of CPR, and application of pads to the victim. Further studies are necessary to determine the long-term viability of such a program, its psychological impact on both volunteers and neighborhoods and, importantly, whether this initial experience in a highly motivated, upscale retirement community is generalizable to more racially, ethnically, economically, and age diverse neighborhoods.

Conclusions

A local neighborhood volunteer network for responding to residential community CA victims had shorter distances to travel than the local professional EMS service and, hence, had significantly shorter times from 'alert to arrival' at the mock victim's residential location.

Conflicts of Interest:

Karl B. Kern, MD is a principal of CardioSpark, LLC, a newly formed start-up company pursuing the formation of such community response networks.

Thomas P. Colberg is the CEO of CardioSpark, LLC

Charles Wunder, Jr., is Chief of the Green Valley Fire Fighters

Cater Newton, MD is the founder and president of CardioSpark, LLC

Marvin J. Slepian, MD is a principal of CardioSpark, LLC

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Figure Legends

Figure 1. A map of “The Springs” showing locations of the mock trials in Phase 1 (blue dots) and the community AED (red heart).