Augmented survival of out-of-hospital cardiac arrest victims with the use of mobile phones for emergency communication under the DA-CPR protocol getting information from callers beside the victim

Manuscript Number: RESUS-D-16-00266R2

Title: Augmented survival of out-of-hospital cardiac arrest victims with the use of mobile phones for emergency communication under the DA-CPR protocol getting information from callers beside the victim

Article Type: Original Article

Keywords: out-of-hospital cardiac arrest, dispatcher-assisted cardiopulmonary resuscitation, emergency call, mobile phone

Corresponding Author: Prof. Hideo Inaba, M.D., Ph.D.

Corresponding Author's Institution: Kanazawa University Graduate School of Medicine

First Author: Tetsuo Maeda, MD, PhD

Order of Authors: Tetsuo Maeda, MD, PhD; Akira Yamashita, MD; Yasuhiro Myojo, MD, PhD; Yukihiro Wato, MD, PhD; Hideo Inaba, M.D., Ph.D.

Abstract: Purpose: To investigate the impacts of emergency calls made using mobile phones on the quality of dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) and survival from out-of-hospital cardiac arrests (OHCAs) that were not witnessed by emergency medical service (EMS).
Methods: In this prospective study, we collected data for 2,530 DA-CPR-attempted medical emergency cases (517 using mobile phones and 2,013 using landline phones) and 2,980 non-EMS-witnessed OHCAs (600 using mobile phones and 2,380 using landline phones). Time factors and quality of DA-CPR, backgrounds of callers and outcomes of OHCAs were compared between mobile and landline phone groups.
Results: Emergency calls are much more frequently placed beside the arrest victim in mobile phone group (52.7% vs. 17.2%). The positive predictive value and acceptance rate of DA-CPR in mobile phone group (84.7% and 80.6%, respectively) were significantly higher than those in landline group (79.2% and 70.9%). The proportion of good-quality bystander CPR in mobile phone group was significantly higher than that in landline group (53.5% vs. 45.0%). When analysed for all non-EMS-witnessed OHCAs, rates of 1-month survival and 1-year neurologically favourable survival in mobile phone group (7.8% and 3.5%, respectively) were higher than those in landline phone group (4.6% and 1.9%; $p < 0.05$). Multiple logistic regression analysis, including other backgrounds, revealed that mobile phone calls were associated with increased 1-month survival in the subgroup of OHCAs receiving bystander CPR (adjusted odds ratio, 1.84; 95% CI, 1.15-2.92).
Conclusion: Emergency calls made using mobile phones are likely to augment the survival from OHCAs by improving DA-CPR.

Aug 8, 2016

Prof. Gavin Perkins
Editor,
Resuscitation

Dear Prof. Perkins,

We wish to express our strong appreciation to you and the reviewers again for giving us an opportunity to make a revision on our paper RESUS-D-16-00266R1 entitled" Augmented survival of out-of-hospital cardiac arrest victims with the use of mobile phones for emergency communication under the DA-CPR protocol getting information from callers beside the victim" and helpful comments.

We attach a revised version showing the marked changes and, separately list our point-by-point responses. We feel that the comments have helped us to improve the paper and hope you convey our gratitude to the reviewers.

All authors made substantial contributions to this revision, including (1) the interpretation of data, (2) revising the article critically for important intellectual content, (3) final approval of the revised version to be submitted.

Yours sincerely,

Hideo Inaba, MD, PhD, Professor and Chair
Department of Emergency Medical Science,
Kanazawa University Graduate School of Medicine
13-1 Takara-machi, Kanazawa, Ishikawa 920-8641, Japan
Phone: +81 76-265-2825 Fax: +81 76-234-4243
Email: hidinaba@med.kanazawa-u.ac.jp

Response to Reviewers' comments

(Manuscript Number: RESUS-D-16-00266R1):

Reviewer 1:

The authors have satisfied me with regards to suitability of full article publication. After reviewing the manuscript, I support its publication in Resuscitation and am pleased we will have additional literature to inform these areas of policy and science. Thank you.

Reply: Thank you for your comments. We made a revision on our paper according to the comments from Reviewer 2. We believe that our manuscript has been improved.

Reviewer 2: Dr R. Fowler

1. You reply at number 5 still has a language error. You should revise the second sentence to say, "A potential reason for the higher incidence of tracheal intubation might be due to a longer duration of on-scene time or time during transportation in the mobile phone group." That reads better.

Reply: We corrected the part of paragraph according to your helpful comment as follows:

Moreover, the rate of performing tracheal intubation was higher in the mobile phone group. A potential reason for the higher incidence of tracheal intubation might be due to a longer duration of on-scene time or time during transportation in the mobile phone group.

2. In number 7 you still have a language problem and combine separate issues. Let me suggest that you modify the sentence this way: "Multivariate logistic regression analysis INCLUDED critical factors such as arrest witness (witnessed or unwitnessed), aetiology (presumed cardiac or non-cardiac), initial ECG rhythm (shockable or not) and BCPR (provided or not). ULTIMATELY, THOUGH the effect of mobile phone calls on 1-Y neurologically favourable survival was not significant." This way you don't combine two competing topics. Otherwise, just re-work the sentence completely.

Reply: Thank you for your comments and suggestion. These competing results or the difference in result between univariate and multivariate analyses may confuse the reader. We carefully revised the part of paragraph as follows:

As shown in Fig. 2, when data for all non-EMS-witnessed OHCAs was analysed by univariate analysis, the rates of 1-M survival and 1-Y neurologically favourable survival were significantly higher in the mobile phone group than in the landline phone group: unadjusted OR; 95% CI, 1.84; 1.09–3.11 for 1-M survival, 1.75; 1.23–2.50 for 1-Y neurologically favourable survival. When arrest witness (witnessed or unwitnessed), aetiology (presumed cardiac or non-cardiac), initial ECG rhythm (shockable or not) and BCPR (provided or not) were included in multivariate logistic regression analysis, this analysis did not confirm the beneficial effect of mobile phone calls on 1-M survival or 1-Y neurologically favourable survival: 1.42; 0.96–2.09, 1.34; 0.73–2.40, respectively.

3. Otherwise, I am satisfied with your modifications and/or explanations.

Reply: We wish to express our strong appreciation to you for giving us an opportunity to make a further revision on our paper.

Augmented survival of out-of-hospital cardiac arrest victims with the use of mobile phones for emergency communication under the DA-CPR protocol getting information from callers beside the victim

Tetsuo Maeda, MD, PhD (1), Akira Yamashita, MD (1), (2), Yasuhiro Myojo, MD, PhD (3), Yukihiro Wato, MD, PhD (4), Hideo Inaba, MD, PhD (1)

(1) Department of Circulatory Emergency and Resuscitation Science, Kanazawa University Graduate School of Medicine, Kanazawa, Ishikawa, Japan

(2) Department of Cardiology, Noto General Hospital, Nanao, Ishikawa, Japan

(3) Emergency Medical Centre, Ishikawa Prefectural Hospital, Kanazawa, Ishikawa, Japan

(4) Department Emergency Medicine, Kanazawa Medical University, Uchinada, Ishikawa, Japan

E-mail: TM; tetsumae@med.kanazawa-u.ac.jp, AY; yamashita@noto-hospital.jp, MY; yasuhiromyojo@yahoo.co.jp, YW; allstar@kanazawa-med.ac.jp, HI; hidinaba@med.kanazawa-u.ac.jp

Address for Correspondence:

Hideo Inaba, MD, PhD, Professor and Chair

Department of Circulatory Emergency and Resuscitation Science,

Kanazawa University Graduate School of Medicine

13-1 Takara-machi, Kanazawa, Ishikawa 920-8641, Japan

Phone: +81-76-265-2825

Fax: +81-76-234-4243

E-mail: hidinaba@med.kanazawa-u.ac.jp

Word count: 2,998

Number of Tables: 3

Number of Figures: 3

Number of references: 29

Abstract

Purpose: To investigate the impacts of emergency calls made using mobile phones on the quality of dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) and survival from out-of-hospital cardiac arrests (OHCAs) that were not witnessed by emergency medical service (EMS).

Methods: In this prospective study, we collected data for 2,530 DA-CPR-attempted medical emergency cases (517 using mobile phones and 2,013 using landline phones) and 2,980 non-EMS-witnessed OHCAs (600 using mobile phones and 2,380 using landline phones). Time factors and quality of DA-CPR, backgrounds of callers and outcomes of OHCAs were compared between mobile and landline phone groups.

Results: Emergency calls are much more frequently placed beside the arrest victim in mobile phone group (52.7% vs. 17.2%). The positive predictive value and acceptance rate of DA-CPR in mobile phone group (84.7% and 80.6%, respectively) were significantly higher than those in landline group (79.2% and 70.9%). The proportion of good-quality bystander CPR in mobile phone group was significantly higher than that in landline group (53.5% vs. 45.0%). When analysed for all non-EMS-witnessed OHCAs, rates of 1-month survival and 1-year neurologically favourable survival in mobile phone group (7.8% and 3.5%, respectively) were higher than those in landline phone group (4.6% and 1.9%; $p < 0.05$). Multiple logistic regression analysis, including other backgrounds, revealed that mobile phone calls were associated with increased 1-month survival in the subgroup of OHCAs receiving bystander CPR (adjusted odds ratio, 1.84; 95% CI, 1.15–2.92).

Conclusion: Emergency calls made using mobile phones are likely to augment the survival from OHCAs by improving DA-CPR.

Word count: 250

Key words: out-of-hospital cardiac arrest, dispatcher-assisted cardiopulmonary resuscitation, emergency call, mobile phone

Introduction

Dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) may improve out-of-hospital cardiac arrest (OHCA) outcome by increasing the bystander CPR (BCPR) frequency.[1–5] To effectively administer an early BCPR, dispatchers are recommended to obtain the exact information about consciousness and breathing of the patient. This crucial communication between callers and dispatchers, via the phone, can be affected by various factors, such as the caller's position or distance from the patient;[4, 5] the OHCA patient having agonal breathing, anoxic convulsions or emesis;[4] the bystander's physical limitations or emotional stress[6] and the bystander's lack of prior CPR training.[7]

The medical control council in Ishikawa Prefecture is extremely proactive in improving the quality of DA-CPR, a procedure which is associated with a better outcome of OHCA patients.[4, 5] A review of the advanced DA-CPR protocol[5] highlighted the importance of collecting accurate real-time information from the caller present in the proximity of the patient and providing the appropriate CPR instructions to the caller. Therefore, we recommended that after identification of the location of the patients, dispatchers should request the callers and bystanders to move close to the patients with suspected cardiac arrest or any other life-threatening emergency.[8]

Traditionally, telephonic activation of emergency medical services (EMS) has been performed primarily by the use of landline phones. However, widespread use of mobile phones has increased the rate of emergency calls made using mobile phones. Although there are many disadvantages of emergency calls made using mobile phones, such as lack of precise location information, unstable signal transmission, misdirected connection to adjacent fire department and running out of battery, have been reported,[9, 10] recent advances in mobile phone technology have resulted in improved quality of communication, thus decreasing some of these disadvantages.[11] Emergency calls made using mobile phones make it easier for the caller to move closer to the patient, which helps the dispatchers to give on-line feedback on BCPR. Furthermore, the recent guidelines on first aid and CPR recommended that bystanders should stay at the patient side and use their cell phone to activate EMS while starting CPR. [12, 13] However, this recommendation is based on theoretical consideration but not on sufficient clinical evidence.

This study aimed to elucidate whether emergency calls made using mobile phones may affect the quality of DA-CPR and BCPR and the outcome of OHCAs. In this study, we integrated information from two extended databases for DA-CPR and OHCA to analyse the benefit of emergency calls made using mobile phones.

Methods

The data were collected in accordance with the national guidelines of ethics for epidemiological surveys.[14] This study was approved by the review board of the Ishikawa Medical Control Council.

Populations and setting

The Ishikawa Prefecture encompasses an area of 4,186 km^2, with a resident population of 1,170,000. There are 11 fire departments in this area, all of which have a single-tiered ambulance dispatch system. Emergency medical technicians (EMTs) resuscitate patients with OHCA according to the protocol based on the guidelines of the Japan Resuscitation Council.[15] All fire departments conducted DA-CPR according to the protocol revised by the Ishikawa Medical Control Council in the beginning of 2012. This revised protocol re-emphasised the following procedures: i) when cardiac arrest was suspected but uncertain, dispatchers should request bystanders to move close to the patients and obtain more accurate and real-time information on responsiveness and respiration; ii) in cases with impending cardiac arrest, dispatchers should instruct bystanders to observe the patient in their proximity and redial the emergency phone number (119 in Japan) if the patient's condition deteriorates; iii) depending on other priorities of the EMS system, dispatchers should stay on the telephone with any callers reporting possibly life-threatening medical emergencies; iv) dispatchers should provide on-line feedback to bystanders when they instruct chest-compression-only CPR.

EMTs are not permitted to terminate resuscitation in the field. The paramedics are authorised to perform the following procedures during the resuscitation: i) use of suprapharyngeal airways, ii) infusion of Ringer's lactate and iii) use of semi-automated external defibrillators. Since July 2004, specially trained paramedics have been permitted to insert tracheal tubes under limited indication criteria; since April 2006, they have been permitted to administer intravenous adrenaline. In all fire departments, each ambulance is usually boarded with three or more EMTs including at least one paramedic.

DA-CPR and patient data

Baseline data were prospectively collected by fire departments in the Ishikawa Prefecture for OHCAs from January 2012 to December 2014. The DA-CPR database included the following information: time intervals (receipt of call to dispatch and receipt of call to DA-CPR), backgrounds of patients and callers and information suggestive of cardiac arrest. The OHCA data were collected according to the Utstein template[16, 17] and included the location, patient's age and gender, witness status, aetiologies of arrest (presumed cardiac or not), origin of BCPR (with or without DA-CPR), type of BCPR, initial cardiac rhythm, estimated time of collapse or arrest recognition, time of the initiation of CPR by bystanders and EMTs, time interval between the emergency call and arrival of medical help at the patient's location, sustained return of spontaneous circulation (ROSC), 1-month (1-M) survival and neurologically favourable 1-year (1-Y) survival determined as per the Pittsburgh cerebral performance category (CPC). Clock time recordings, except those based on estimations, were recorded in seconds. In this study, sustained ROSC was defined as the continuous presence of palpable pulses for more than 20 min. The survival rate at 1-Y was defined as the patient being alive in a hospital at 1-Y or as the patient being alive and discharged from the hospital to home or to a care or rehabilitation facility within 1-Y. One-year survival with a neurologically favourable outcome was defined as a CPC of one (good recovery) or two (moderate disability) in patients without any neurological disturbance before the arrest event. In patients with a pre-existing neurological disturbance, the neurologically favourable outcome was judged to be achieved when the final CPC was equal to the pre-arrest category. The primary end-point was 1-Y survival with neurologically favourable outcomes, whereas the secondary end point was 1-M survival.

The chest compression quality was evaluated by EMTs when they arrived at the scene. The quality was considered to be good when all the following three criteria were fulfilled: i) appropriate hand position, ii) a compression rate of at least 100/min and iii) a compression depth of at least 2 inches (5 cm) or at least one-third of the anterior–posterior diameter of the chest. The quality of chest compressions was considered to be identical to the quality of BCPR because BCPR following DA-CPR was essentially chest-compression-only CPR in our community. [18] Moreover, EMTs ensured that bystander information, such as age and gender, relationship to the OHCA patient and total number of rescuers, was collected in collaboration with dispatcher, as we previously reported. [19]

Statistical analysis

We analysed the data using JMP ver.11 Pro for Windows (SAS institute, Cary, NC). The chi-squared test with and without Yates' correction or Fisher exact probability tests were applied for univariate analyses. The Kruskal–Wallis test was used for non-parametric comparisons. We used a multiple logistic regression analysis to identify the factors associated with good-quality

BCPR. In all analyses, $p < 0.05$ was considered to be significant. Odds ratio (OR) and 95% confidence interval (95% CI) were shown when they were defined.

Results

Overview

As illustrated at the top of Fig. 1, DA-CPR was attempted in 3,012 cases. Of these, 482 cases were not transported to a hospital because of the presence of post-mortem changes and were excluded from analysis. Of 2,530 cases that were transported to hospital, emergency calls for 517 cases were made using mobile phones and for 2,013 cases using landline phones. Of the total cases, 79 (15.2%) in the mobile phone group and 419 (20.8%) in the landline phone group were not in cardiac arrest. The rates of bystander agreeing to perform DA-CPR (the acceptance rate of DA-CPR) were 80.6% (353/438) in the mobile phone group and 70.8% (1,130/1,594) in the landline group that presented with cardiac arrest on EMS arrival at patients.

As shown in the middle panel of Fig. 1, bystander initiated CPR without DA-CPR was administered to only 53 (8.8%) of 600 non-EMS-witnessed OHCA cases in the mobile phone group and 296 (12.4%) of 2,380 cases in the landline phone group. The lack of BCPR could be attributed to the inability to provide DA-CPR for 109 (56.2%) of 194 cases in the mobile phone group and 490 (51.4%) of 954 cases in the landline phone group. DA-CPR was attempted in 438 (73.0%) of 600 non-EMT-witnessed OHCA cases in the mobile phone group and in 1,594 (67.0%) of 2,380 OHCA cases in the landline phone group. The overall rate of BCPR in our community was 61.5% (1,832/2,980), of which 67.7% (406/600) were in the mobile phone group and 59.9% (1,426/2,380) in the landline phone group.

Parameters and indexes related to DA-CPR and BCPR have been summarized in Table 1. Positive predictive value and acceptance rate of DA-CPR were found to be significantly higher in the mobile phone group than in the landline phone group: unadjusted OR; 95% CI, 1.46; 1.12–1.90 for positive predictive value, 1.71; 1.31–2.11 for acceptance rate of DA-CPR.

Backgrounds and time factors of DA-CPR (Table 2)

We compared the backgrounds and time factors of DA-CPR between landline and mobile phone groups using the DA-CPR database. The patients in the mobile phone group were significantly younger than those in the landline phone group. Time intervals between receipt of call and dispatch and between receipt of call and DA-CPR were longer in the mobile phone group than in the landline phone group. However, there was no significant difference in the receipt of call to EMS arrival at patient's location between the two groups. Proportion of emergency calls from third parties including police officers or persons in the other locations than the arrest scene was much higher in the landline phone group than in the mobile phone group. Both responsiveness and respiration were more frequently unknown in the landline phone group. Callers in the landline phone group rarely (2.9%, 58/2,013) redialled using mobile phone to move closer to the patient.

Backgrounds and time factors of non-EMS-witnessed OHCA (Table 3)

We compared the backgrounds and time factors of non-EMS-witnessed OHCA between landline and mobile phone group using the OHCA database. Patients in the mobile phone group were found to be younger and more frequently male than those in landline phone group. OHCA more frequently occurred at home, and the aetiology of OHCA was more frequently presumed to be cardiac in the landline phone group. The bystanders were most likely to be families or relatives in the landline phone group. As expected, emergency calls made from patient's close proximity were found majorly in the mobile phone group. Proportions of BCPR administration and good quality of BCPR were found to be higher in the mobile group. Shockable initial rhythm was more frequently recorded in the mobile phone group along with a higher rate of performing tracheal intubation. The time interval between witness/recognition and call was shorter; however, the duration of transportation was longer in the mobile phone group.

Outcomes of non-EMS-witnessed OHCA

As shown in Fig. 2, when data for all non-EMS-witnessed OHCAs was analysed by univariate analysis, the rates of 1-M survival and 1-Y neurologically favourable survival were significantly higher in the mobile phone group than in the landline phone group: unadjusted OR; 95% CI, 1.84; 1.09–3.11 for 1-M survival, 1.75; 1.23–2.50 for 1-Y neurologically favourable survival. When arrest witness (witnessed or unwitnessed), aetiology (presumed cardiac or non-cardiac), initial ECG rhythm (shockable or not) and BCPR (provided or not) were included in multivariate logistic regression analysis, this analysis did not confirm the beneficial effect of mobile phone calls on 1-M survival or 1-Y neurologically favourable survival: 1.42; 0.96–2.09, 1.34; 0.73–2.40, respectively.

When we analysed non-EMS-witnessed OHCA cases receiving BCPR by univariate analysis, we found that the 1-M survival rate in the mobile phone group was significantly higher than that in the landline phone group (unadjusted OR, 2.24; 95% CI, 1.47–3.43). As shown in Fig. 3, multivariable logistic regression analysis, including arrest witness, aetiology and initial ECG rhythm, confirmed the advantage of mobile phone calls (adjusted OR, 1.84; 95% CI, 1.15–

2.92). Adjusted OR (95% CI) was 1.81 (1.12–2.88) even when the quality of BCPR, arrest location (home or others) and age group of callers (>60 years or not) were added to the factors included in the analysis.

Discussion

In this study, we showed that the following indexes related to DA-CPR and BCPR were improved when emergency calls were made using a mobile phone under a DA-CPR protocol obtaining information from callers in proximity to the cardiac arrest victim: positive predictive value and acceptance rate of DA-CPR, overall rate of BCPR and rate of BCPR with good quality. Furthermore, responsiveness and respiration were less frequently unknown when the emergency call was made using a mobile phone. Moreover, the rate of performing tracheal intubation was higher in the mobile phone group. A potential reason for the higher incidence of tracheal intubation might be due to a longer duration of on-scene time or time during transportation in the mobile phone group. Although presumed cardiac aetiology was less frequently recorded, the initial rhythm was more frequently shockable in the mobile phone group. Finally, in univariate analysis, emergency calls made using mobile phones were associated with better outcomes including higher rates of 1-M survival and neurologically favourable 1-Y survival in all non-EMS-witnessed OHCAs and higher rate of 1-M survival in the subgroup receiving BCPR. In multiple logistic regression analysis, the beneficial effects of emergency calls made using mobile phones on long term outcomes were not significant for all non-EMS-witnessed OHCAs, but the effect on 1-M survival from the OHCA receiving BCPR was significant.

We found disadvantages of emergency calls made using mobile phones. The time intervals between receipt of call and dispatch and between receipt of call and DA-CPR were slightly but significantly prolonged, compared with calls made using landline phones. Most of the dispatch systems in our fire departments have the latest data for landline phone number and address in the community. When the system receives a landline emergency call, it automatically displays the address. When the system receives a mobile phone emergency call, it obtains only rough GPS location, which requires the dispatchers to explore the exact location using a digital map. This difference in the identification process for the location of the patient is the main reason for the prolonged time intervals. Improvement of GPS accuracy as reported in the urban area of Japan may minimize this disadvantage. [20]

Despite these disadvantages, our data suggest that there may be a benefit of using mobile phones to activate EMS in all areas where signal stability is available. Recently, guidelines on first aid and CPR in UK[21–23] recommended the callers to stay with the arrest victim and to activate the speaker phone function. These actions were easily adopted by the callers with mobile and wireless landline phones. However, in our study population, it was observed that bystanders do not necessarily place an emergency call when they are in the proximity of the patient. Furthermore, elderly bystanders are often unaware of how to activate speaker phone function. [24] We disclosed that emergency calls are much more frequently placed beside the arrest victim when bystanders use a mobile phone. Moreover, this is the biggest advantage of the mobile phones that associated with the improved qualities of DA-CPR and BCPR. Therefore, it is recommended that educational course for basic life support should include the emphasis on placing an emergency call within close proximity of the arrest victims using mobile or wireless landline phones and educating them about how to activate speaker phone function.

A single rescuer with no mobile phone is recommended to perform BCPR for 2 min before making emergency call in the cases of unwitnessed paediatric OHCA (CPR-first action).[25] In the other OHCA cases, it is recommended to activate EMS first and then to perform BCPR (call-first action).[12, 13] Our previous study demonstrated that immediate BCPR that was initiated without DA-CPR and followed by an emergency call without a large delay was associated with a better outcome of bystander-witnessed OHCAs in nonelderly patients and of noncardiac aetiology.[26] In these cases, mobile phones may allow these well trained rescuers to perform BCPR and to activate EMS simultaneously.

Limitations

First, although our data were derived from a 3-year prospective cohort database in our community with a population of approximately one million, the number of OHCAs was too small to clarify the definitive effects of mobile phone calls on the study outcomes. Second, younger bystanders appeared to use mobile phones more frequently. It is highly possible that this difference may influence the quality of BCPR and DA-CPR[27] and its outcome, although multiple logistic regression analysis, including the bystander's age, confirmed the beneficial effect of mobile phone calls on 1-M survival in non-EMS-witnessed OHCAs receiving BCPR. Finally, it was difficult to obtain the information of bystanders' previous training experience for basic life support (BLS) in all non-EMS-witnessed OHCAs, which may influence their willingness to perform CPR and quality of BCPR.[28, 29]

Conclusions

Emergency calls made using mobile phones are likely to augment the short term survival from OHCAs by improving the acceptance rate and quality of DA-CPR. It should be instructed in BLS training courses that an emergency call should be made from close proximity of the patient. Accordingly, we have made changes to our DA-CPR protocol by adding clear statements that the dispatchers should request bystanders to redial 119 using mobile or wireless phones after they move close to the patients and to activate the speaker phone function when cardiac arrest was suspected, but not confirmed.

Conflict of interest

The authors declare no conflict of interest to disclose.

Acknowledgements

We would like to thank all the EMS personnel in Ishikawa Prefecture for their cooperation. TM and AY equally contributed to this article as the first authors.

References

1. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. Circulation 2001;104:2513-6.
2. Vaillancourt C, Verma A, Trickett J, et al. Evaluating the effectiveness of dispatch-assisted cardiopulmonary resuscitation instructions. Acad Emerg Med 2007;14:877-83.
3. Bohm K, Vaillancourt C, Charette ML, Dunford J, Castrén M. In patients with out-of-hospital cardiac arrest, does the provision of dispatch cardiopulmonary resuscitation instructions as opposed to no instructions improve outcome: A systematic review of the literature. Resuscitation 2011;82:1483-9.
4. Tanaka Y, Taniguchi J, Wato Y, Yoshida Y, Inaba H. The continuous quality improvement project for telephone-assisted instruction of cardiopulmonary resuscitation increased the incidence of bystander CPR and improved the outcomes of out-of-hospital cardiac arrests. Resuscitation 2012;83:1235-41.
5. Tanaka Y, Nishi T, Takase K, et al. Survey of a protocol to increase appropriate implementation of dispatcher-assisted cardiopulmonary resuscitation for out-of-hospital cardiac arrest. Circulation 2014;129:1751-60.
6. Hauff SR, Rea TD, Culley LL, et al. Factors impeding dispatcher-assisted telephone cardiopulmonary resuscitation. Ann Emerg Med 2003;42:731-7.
7. Kellermann AL, Hackman BB, Somes G. Dispatcher-assisted cardiopulmonary resuscitation. Validation of efficacy. Circulation 1989;80:1231-9.

8. Takei Y, Nishi T, Kamikura T, et al. Do early emergency calls before patient collapse improve survival after out-of-hospital cardiac arrest? Resuscitation 2015;88:20-7.

9. Calling the Emergency Call Service from a mobile phone: FAQs. Australian Communications and Media Authority, 2015. (Accessed 18 February 2016, at External link http://www.acma.gov.au/theACMA/calling-the-emergency-call-service-from-a-mobile-phone--faqs)

10. Kyoto Prefecture Police Headquarters. Dial 110 emergency call placed by mobile phone. Kyoto Prefecture Police, 2015. (Accessed 18 February 2016, at External link http://www.pref.kyoto.jp/fukei/foreign/tusi_c/110/mobile.html)

11. Strategies for future spectrum management in Japan. Ministry of Internal Affairs and Communications, Japan, 2007. (Accessed 18 February 2016, at External link http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/presentation/pdf/070713_1.pdf)

12. Kleinman ME, Brennan EE, Goldberger ZD, et al. Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary resuscitation and Emergency Cardiovascular Care. Circulation 2015;132:S414-35.

13. Perkins GD, Handley AJ, Koster RW, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. Resuscitation 2015;95:81-99.

14. Ministry of Education, Culture, Sports, Science and Technology. Ethical guidelines for epidemiological research. Ministry of Health, Labour and Welfare, Japan, 2002. (Accessed 18 February 2016, at External link http://www.niph.go.jp/wadai/ekigakurinri/guidelines.pdf)

15. Working Group of Japan resuscitation Council. JRC guidelines 2010. Japan Resuscitation Council, 2010. (Accessed 18 February 2016, at External link http://www.qqzaidan.jp/pdf_5/guideline1_BLS_kakutei.pdf)

16. Chamberlain D, Cummins RO, Abramson N, et al. Recommended Guidelines for uniform reporting of data from out-of-hospital cardiac arrest: the 'Utstein style': Prepared by a Task Force of Representatives from the European Resuscitation Council, American Heart Association, Heart and Stroke Foundation of Canada, Australian Resuscitation Council. Resuscitation 1991;22:1-29.

17. Jacobs I, Nadkarni V, Bahr J, the ILCOR Task Force on Cardiac Arrest and Cardiopulmonary Resuscitation Outcomes. Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update and Simplification of the Utstein Templates for Resuscitation Registries: a Statement for Healthcare Professionals from a Task Force of the International Liaison Committee on Resuscitation. Circulation 2004;110:3385–97.

18. Takei Y, Nishi T, Matsubara H, Hashimoto M, Inaba H. Factors associated with quality of bystander CPR: The presence of multiple rescuers and bystander-initiated CPR without instruction. Resuscitation 2014;85:492-8.

19. Nishi T, Maeda T, Takase K, et al. Does the number of rescuers affect the survival rate from out-of-hospital cardiac arrests? Two or more rescuers are not always better than one. Resuscitation 2013;84:154-61.

20. Takeuchi Y. Director of Space Communications Policy Division. Space Communications Policies in Japan. Ministry of Internal Affairs and Communications, Japan, 2006. (Accessed

18 February 2016, at External link http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/presentation/pdf/070713_1.pdf)

21. 5 Ways a Mobile Phone can save your life. REAL First Aid ltd, UK, 2015. (Accessed 18 February 2016, at External link http://www.realfirstaid.co.uk/mobile-phone/)

22. Working Group of the Resuscitation Council (UK). Adult basic life support and automated external defibrillation. Resuscitation Council (UK), 2015. (Accessed 18 February 2016, at External link https://www.resus.org.uk/resuscitation-guidelines/adult-basic-life-support-and-automated-external-defibrillation/#sequence)

23. Working Group of Resuscitation Council (UK). Guidelines 2010. Resuscitation Council (UK), 2010. (Accessed 18 February 2016, at External link https://www.resus.org.uk/archive/guidelines-2010/)

24. Birkenes TS, Myklebust H, Kramer-Johansen J. Time delays and capability of elderly to activate speaker function for continuous telephone CPR. Scand J Trauma Resusc Emerg Med. 2013;21:40.

25. Atkins DL, Berger S, Duff JP, et al. Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Cirlucation 2015;132:S519-25.

26. Kamikura T, Iwasaki H, Myojo Y, et al. Advantage of CPR-first over call-first actions for out-of-hospital cardiac arrests in nonelderly patients and on noncardiac aetiology. Resuscitation 2015;96:37-45.

27. Enami M, Takei Y, Inaba H, et al. Differential effects of ageing and BLS training experience on attitude towards basic life support. Resuscitation 2011;82:577-83.

28. Enami M, Takei Y, Goto Y, Ohta K, Inaba H. The effects of the new CPR guideline on attitude toward basic life support in Japan. Resuscitation 2010;81:562-7.

29. Ro YS, Shin SD, Song KJ, et al. Public awareness and self-efficacy of cardiopulmonary resuscitation in communities and outcomes of out-of-hospital cardiac arrest: A multi-level analysis. Resuscitation 2016;102:17-24.

Figure legends:

Figure 1: Overview of the study design.

Analysis of data related to dispatcher-assisted cardiopulmonary resuscitation begins from the top, and analysis of data pertaining to non-EMS-witnessed out-of-hospital cardiac arrest (OHCA) cases starts from the bottom.

Figure 2: Outcomes of non-EMS-witnessed OHCAs where emergency calls were made using mobile and landline phones.

Closed star symbols indicate significant difference by chi-square test or Fisher's exact probability test.

Figure 3: Multivariate logistic regression analysis for 1-month survival from non-EMS-witnessed OHCAs receiving BCPR.

Augmented survival of out-of-hospital cardiac arrest victims with the use of mobile phones for emergency communication under the DA-CPR protocol getting information from callers beside the victim

Tetsuo Maeda, MD, PhD (1), Akira Yamashita, MD (1), (2), Yasuhiro Myojo, MD, PhD (3), Yukihiro Wato, MD, PhD (4), Hideo Inaba, MD, PhD (1)

(1) Department of Circulatory Emergency and Resuscitation Science, Kanazawa University Graduate School of Medicine, Kanazawa, Ishikawa, Japan

(2) Department of Cardiology, Noto General Hospital, Nanao, Ishikawa, Japan

(3) Emergency Medical Centre, Ishikawa Prefectural Hospital, Kanazawa, Ishikawa, Japan

(4) Department Emergency Medicine, Kanazawa Medical University, Uchinada, Ishikawa, Japan

E-mail: TM; tetsumae@med.kanazawa-u.ac.jp, AY; yamashita@noto-hospital.jp, MY; yasuhiromyojo@yahoo.co.jp, YW; allstar@kanazawa-med.ac.jp, HI; hidinaba@med.kanazawa-u.ac.jp

Address for Correspondence:

Hideo Inaba, MD, PhD, Professor and Chair

Department of Circulatory Emergency and Resuscitation Science,

Kanazawa University Graduate School of Medicine

13-1 Takara-machi, Kanazawa, Ishikawa 920-8641, Japan

Phone: +81-76-265-2825

Fax: +81-76-234-4243

E-mail: hidinaba@med.kanazawa-u.ac.jp

Word count: 2,998

Number of Tables: 3

Number of Figures: 3

Number of references: 29

Abstract

Purpose: To investigate the impacts of emergency calls made using mobile phones on the quality of dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) and survival from out-of-hospital cardiac arrests (OHCAs) that were not witnessed by emergency medical service (EMS).

Methods: In this prospective study, we collected data for 2,530 DA-CPR-attempted medical emergency cases (517 using mobile phones and 2,013 using landline phones) and 2,980 non-EMS-witnessed OHCAs (600 using mobile phones and 2,380 using landline phones). Time factors and quality of DA-CPR, backgrounds of callers and outcomes of OHCAs were compared between mobile and landline phone groups.

Results: Emergency calls are much more frequently placed beside the arrest victim in mobile phone group (52.7% vs. 17.2%). The positive predictive value and acceptance rate of DA-CPR in mobile phone group (84.7% and 80.6%, respectively) were significantly higher than those in landline group (79.2% and 70.9%). The proportion of good-quality bystander CPR in mobile phone group was significantly higher than that in landline group (53.5% vs. 45.0%). When analysed for all non-EMS-witnessed OHCAs, rates of 1-month survival and 1-year neurologically favourable survival in mobile phone group (7.8% and 3.5%, respectively) were higher than those in landline phone group (4.6% and 1.9%; $p < 0.05$). Multiple logistic regression analysis, including other backgrounds, revealed that mobile phone calls were associated with increased 1-month survival in the subgroup of OHCAs receiving bystander CPR (adjusted odds ratio, 1.84; 95% CI, 1.15–2.92).

Conclusion: Emergency calls made using mobile phones are likely to augment the survival from OHCAs by improving DA-CPR.

Word count: 250

Key words: out-of-hospital cardiac arrest, dispatcher-assisted cardiopulmonary resuscitation, emergency call, mobile phone

Introduction

Dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) may improve out-of-hospital cardiac arrest (OHCA) outcome by increasing the bystander CPR (BCPR) frequency.[1–5] To effectively administer an early BCPR, dispatchers are recommended to obtain the exact information about consciousness and breathing of the patient. This crucial communication between callers and dispatchers, via the phone, can be affected by various factors, such as the caller's position or distance from the patient;[4, 5] the OHCA patient having agonal breathing, anoxic convulsions or emesis;[4] the bystander's physical limitations or emotional stress[6] and the bystander's lack of prior CPR training.[7]

The medical control council in Ishikawa Prefecture is extremely proactive in improving the quality of DA-CPR, a procedure which is associated with a better outcome of OHCA patients.[4, 5] A review of the advanced DA-CPR protocol[5] highlighted the importance of collecting accurate real-time information from the caller present in the proximity of the patient and providing the appropriate CPR instructions to the caller. Therefore, we recommended that after identification of the location of the patients, dispatchers should request the callers and bystanders to move close to the patients with suspected cardiac arrest or any other life-threatening emergency.[8]

Traditionally, telephonic activation of emergency medical services (EMS) has been performed primarily by the use of landline phones. However, widespread use of mobile phones has increased the rate of emergency calls made using mobile phones. Although there are many disadvantages of emergency calls made using mobile phones, such as lack of precise location information, unstable signal transmission, misdirected connection to adjacent fire department and running out of battery, have been reported,[9, 10] recent advances in mobile phone technology have resulted in improved quality of communication, thus decreasing some of these disadvantages.[11] Emergency calls made using mobile phones make it easier for the caller to move closer to the patient, which helps the dispatchers to give on-line feedback on BCPR. Furthermore, the recent guidelines on first aid and CPR recommended that bystanders should stay at the patient side and use their cell phone to activate EMS while starting CPR. [12, 13] However, this recommendation is based on theoretical consideration but not on sufficient clinical evidence.

This study aimed to elucidate whether emergency calls made using mobile phones may affect the quality of DA-CPR and BCPR and the outcome of OHCAs. In this study, we integrated information from two extended databases for DA-CPR and OHCA to analyse the benefit of emergency calls made using mobile phones.

Methods

The data were collected in accordance with the national guidelines of ethics for epidemiological surveys.[14] This study was approved by the review board of the Ishikawa Medical Control Council.

Populations and setting

The Ishikawa Prefecture encompasses an area of 4,186 km^2, with a resident population of 1,170,000. There are 11 fire departments in this area, all of which have a single-tiered ambulance dispatch system. Emergency medical technicians (EMTs) resuscitate patients with OHCA according to the protocol based on the guidelines of the Japan Resuscitation Council.[15] All fire departments conducted DA-CPR according to the protocol revised by the Ishikawa Medical Control Council in the beginning of 2012. This revised protocol re-emphasised the following procedures: i) when cardiac arrest was suspected but uncertain, dispatchers should request bystanders to move close to the patients and obtain more accurate and real-time information on responsiveness and respiration; ii) in cases with impending cardiac arrest, dispatchers should instruct bystanders to observe the patient in their proximity and redial the emergency phone number (119 in Japan) if the patient's condition deteriorates; iii) depending on other priorities of the EMS system, dispatchers should stay on the telephone with any callers reporting possibly life-threatening medical emergencies; iv) dispatchers should provide on-line feedback to bystanders when they instruct chest-compression-only CPR.

EMTs are not permitted to terminate resuscitation in the field. The paramedics are authorised to perform the following procedures during the resuscitation: i) use of suprapharyngeal airways, ii) infusion of Ringer's lactate and iii) use of semi-automated external defibrillators. Since July 2004, specially trained paramedics have been permitted to insert tracheal tubes under limited indication criteria; since April 2006, they have been permitted to administer intravenous adrenaline. In all fire departments, each ambulance is usually boarded with three or more EMTs including at least one paramedic.

DA-CPR and patient data

Baseline data were prospectively collected by fire departments in the Ishikawa Prefecture for OHCAs from January 2012 to December 2014. The DA-CPR database included the following information: time intervals (receipt of call to dispatch and receipt of call to DA-CPR), backgrounds of patients and callers and information suggestive of cardiac arrest. The OHCA data were collected according to the Utstein template[16, 17] and included the location, patient's age and gender, witness status, aetiologies of arrest (presumed cardiac or not), origin of BCPR (with or without DA-CPR), type of BCPR, initial cardiac rhythm, estimated time of collapse or arrest recognition, time of the initiation of CPR by bystanders and EMTs, time interval between the emergency call and arrival of medical help at the patient's location, sustained return of spontaneous circulation (ROSC), 1-month (1-M) survival and neurologically favourable 1-year (1-Y) survival determined as per the Pittsburgh cerebral performance category (CPC). Clock time recordings, except those based on estimations, were recorded in seconds. In this study, sustained ROSC was defined as the continuous presence of palpable pulses for more than 20 min. The survival rate at 1-Y was defined as the patient being alive in a hospital at 1-Y or as the patient being alive and discharged from the hospital to home or to a care or rehabilitation facility within 1-Y. One-year survival with a neurologically favourable outcome was defined as a CPC of one (good recovery) or two (moderate disability) in patients without any neurological disturbance before the arrest event. In patients with a pre-existing neurological disturbance, the neurologically favourable outcome was judged to be achieved when the final CPC was equal to the pre-arrest category. The primary end-point was 1-Y survival with neurologically favourable outcomes, whereas the secondary end point was 1-M survival.

The chest compression quality was evaluated by EMTs when they arrived at the scene. The quality was considered to be good when all the following three criteria were fulfilled: i) appropriate hand position, ii) a compression rate of at least 100/min and iii) a compression depth of at least 2 inches (5 cm) or at least one-third of the anterior–posterior diameter of the chest. The quality of chest compressions was considered to be identical to the quality of BCPR because BCPR following DA-CPR was essentially chest-compression-only CPR in our community. [18] Moreover, EMTs ensured that bystander information, such as age and gender, relationship to the OHCA patient and total number of rescuers, was collected in collaboration with dispatcher, as we previously reported. [19]

Statistical analysis

We analysed the data using JMP ver.11 Pro for Windows (SAS institute, Cary, NC). The chi-squared test with and without Yates' correction or Fisher exact probability tests were applied for univariate analyses. The Kruskal–Wallis test was used for non-parametric comparisons. We used a multiple logistic regression analysis to identify the factors associated with good-quality

BCPR. In all analyses, $p < 0.05$ was considered to be significant. Odds ratio (OR) and 95% confidence interval (95% CI) were shown when they were defined.

Results

Overview

As illustrated at the top of Fig. 1, DA-CPR was attempted in 3,012 cases. Of these, 482 cases were not transported to a hospital because of the presence of post-mortem changes and were excluded from analysis. Of 2,530 cases that were transported to hospital, emergency calls for 517 cases were made using mobile phones and for 2,013 cases using landline phones. Of the total cases, 79 (15.2%) in the mobile phone group and 419 (20.8%) in the landline phone group were not in cardiac arrest. The rates of bystander agreeing to perform DA-CPR (the acceptance rate of DA-CPR) were 80.6% (353/438) in the mobile phone group and 70.8% (1,130/1,594) in the landline group that presented with cardiac arrest on EMS arrival at patients.

As shown in the middle panel of Fig. 1, bystander initiated CPR without DA-CPR was administered to only 53 (8.8%) of 600 non-EMS-witnessed OHCA cases in the mobile phone group and 296 (12.4%) of 2,380 cases in the landline phone group. The lack of BCPR could be attributed to the inability to provide DA-CPR for 109 (56.2%) of 194 cases in the mobile phone group and 490 (51.4%) of 954 cases in the landline phone group. DA-CPR was attempted in 438 (73.0%) of 600 non-EMT-witnessed OHCA cases in the mobile phone group and in 1,594 (67.0%) of 2,380 OHCA cases in the landline phone group. The overall rate of BCPR in our community was 61.5% (1,832/2,980), of which 67.7% (406/600) were in the mobile phone group and 59.9% (1,426/2,380) in the landline phone group.

Parameters and indexes related to DA-CPR and BCPR have been summarized in Table 1. Positive predictive value and acceptance rate of DA-CPR were found to be significantly higher in the mobile phone group than in the landline phone group: unadjusted OR; 95% CI, 1.46; 1.12–1.90 for positive predictive value, 1.71; 1.31–2.11 for acceptance rate of DA-CPR.

Backgrounds and time factors of DA-CPR (Table 2)

We compared the backgrounds and time factors of DA-CPR between landline and mobile phone groups using the DA-CPR database. The patients in the mobile phone group were significantly younger than those in the landline phone group. Time intervals between receipt of call and dispatch and between receipt of call and DA-CPR were longer in the mobile phone group than in the landline phone group. However, there was no significant difference in the receipt of call to EMS arrival at patient's location between the two groups. Proportion of emergency calls from third parties including police officers or persons in the other locations than the arrest scene was much higher in the landline phone group than in the mobile phone group. Both responsiveness and respiration were more frequently unknown in the landline phone group. Callers in the landline phone group rarely (2.9%, 58/2,013) redialled using mobile phone to move closer to the patient.

Backgrounds and time factors of non-EMS-witnessed OHCA (Table 3)

We compared the backgrounds and time factors of non-EMS-witnessed OHCA between landline and mobile phone group using the OHCA database. Patients in the mobile phone group were found to be younger and more frequently male than those in landline phone group. OHCA more frequently occurred at home, and the aetiology of OHCA was more frequently presumed to be cardiac in the landline phone group. The bystanders were most likely to be families or relatives in the landline phone group. As expected, emergency calls made from patient's close proximity were found majorly in the mobile phone group. Proportions of BCPR administration and good quality of BCPR were found to be higher in the mobile group. Shockable initial rhythm was more frequently recorded in the mobile phone group along with a higher rate of performing tracheal intubation. The time interval between witness/recognition and call was shorter; however, the duration of transportation was longer in the mobile phone group.

Outcomes of non-EMS-witnessed OHCA

As shown in Fig. 2, when data for all non-EMS-witnessed OHCAs was analysed by univariate analysis, the rates of 1-M survival and 1-Y neurologically favourable survival were significantly higher in the mobile phone group than in the landline phone group: unadjusted OR; 95% CI, 1.84; 1.09–3.11 for 1-M survival, 1.75; 1.23–2.50 for 1-Y neurologically favourable survival. When arrest witness (witnessed or unwitnessed), aetiology (presumed cardiac or non-cardiac), initial ECG rhythm (shockable or not) and BCPR (provided or not) were included in multivariate logistic regression analysis, this analysis did not confirm the beneficial effect of mobile phone calls on 1-M survival or 1-Y neurologically favourable survival: 1.42; 0.96–2.09, 1.34; 0.73–2.40, respectively.

When we analysed non-EMS-witnessed OHCA cases receiving BCPR by univariate analysis, we found that the 1-M survival rate in the mobile phone group was significantly higher than that in the landline phone group (unadjusted OR, 2.24; 95% CI, 1.47–3.43). As shown in Fig. 3, multivariable logistic regression analysis, including arrest witness, aetiology and initial ECG rhythm, confirmed the advantage of mobile phone calls (adjusted OR, 1.84; 95% CI, 1.15–

2.92). Adjusted OR (95% CI) was 1.81 (1.12–2.88) even when the quality of BCPR, arrest location (home or others) and age group of callers (>60 years or not) were added to the factors included in the analysis.

Discussion

In this study, we showed that the following indexes related to DA-CPR and BCPR were improved when emergency calls were made using a mobile phone under a DA-CPR protocol obtaining information from callers in proximity to the cardiac arrest victim: positive predictive value and acceptance rate of DA-CPR, overall rate of BCPR and rate of BCPR with good quality. Furthermore, responsiveness and respiration were less frequently unknown when the emergency call was made using a mobile phone. Moreover, the rate of performing tracheal intubation was higher in the mobile phone group. A potential reason for the higher incidence of tracheal intubation might be due to a longer duration of on-scene time or time during transportation in the mobile phone group. Although presumed cardiac aetiology was less frequently recorded, the initial rhythm was more frequently shockable in the mobile phone group. Finally, in univariate analysis, emergency calls made using mobile phones were associated with better outcomes including higher rates of 1-M survival and neurologically favourable 1-Y survival in all non-EMS-witnessed OHCAs and higher rate of 1-M survival in the subgroup receiving BCPR. In multiple logistic regression analysis, the beneficial effects of emergency calls made using mobile phones on long term outcomes were not significant for all non-EMS-witnessed OHCAs, but the effect on 1-M survival from the OHCA receiving BCPR was significant.

We found disadvantages of emergency calls made using mobile phones. The time intervals between receipt of call and dispatch and between receipt of call and DA-CPR were slightly but significantly prolonged, compared with calls made using landline phones. Most of the dispatch systems in our fire departments have the latest data for landline phone number and address in the community. When the system receives a landline emergency call, it automatically displays the address. When the system receives a mobile phone emergency call, it obtains only rough GPS location, which requires the dispatchers to explore the exact location using a digital map. This difference in the identification process for the location of the patient is the main reason for the prolonged time intervals. Improvement of GPS accuracy as reported in the urban area of Japan may minimize this disadvantage.[20]

Despite these disadvantages, our data suggest that there may be a benefit of using mobile phones to activate EMS in all areas where signal stability is available. Recently, guidelines on first aid and CPR in UK[21–23] recommended the callers to stay with the arrest victim and to activate the speaker phone function. These actions were easily adopted by the callers with mobile and wireless landline phones. However, in our study population, it was observed that bystanders do not necessarily place an emergency call when they are in the proximity of the patient. Furthermore, elderly bystanders are often unaware of how to activate speaker phone function.[24] We disclosed that emergency calls are much more frequently placed beside the arrest victim when bystanders use a mobile phone. Moreover, this is the biggest advantage of the mobile phones that associated with the improved qualities of DA-CPR and BCPR. Therefore, it is recommended that educational course for basic life support should include the emphasis on placing an emergency call within close proximity of the arrest victims using mobile or wireless landline phones and educating them about how to activate speaker phone function.

A single rescuer with no mobile phone is recommended to perform BCPR for 2 min before making emergency call in the cases of unwitnessed paediatric OHCA (CPR-first action).[25] In the other OHCA cases, it is recommended to activate EMS first and then to perform BCPR (call-first action).[12, 13] Our previous study demonstrated that immediate BCPR that was initiated without DA-CPR and followed by an emergency call without a large delay was associated with a better outcome of bystander-witnessed OHCAs in nonelderly patients and of noncardiac aetiology.[26] In these cases, mobile phones may allow these well trained rescuers to perform BCPR and to activate EMS simultaneously.

Limitations

First, although our data were derived from a 3-year prospective cohort database in our community with a population of approximately one million, the number of OHCAs was too small to clarify the definitive effects of mobile phone calls on the study outcomes. Second, younger bystanders appeared to use mobile phones more frequently. It is highly possible that this difference may influence the quality of BCPR and DA-CPR[27] and its outcome, although multiple logistic regression analysis, including the bystander's age, confirmed the beneficial effect of mobile phone calls on 1-M survival in non-EMS-witnessed OHCAs receiving BCPR. Finally, it was difficult to obtain the information of bystanders' previous training experience for basic life support (BLS) in all non-EMS-witnessed OHCAs, which may influence their willingness to perform CPR and quality of BCPR.[28, 29]

Conclusions

Emergency calls made using mobile phones are likely to augment the short term survival from OHCAs by improving the acceptance rate and quality of DA-CPR. It should be instructed in BLS training courses that an emergency call should be made from close proximity of the patient. Accordingly, we have made changes to our DA-CPR protocol by adding clear statements that the dispatchers should request bystanders to redial 119 using mobile or wireless phones after they move close to the patients and to activate the speaker phone function when cardiac arrest was suspected, but not confirmed.

Conflict of interest

The authors declare no conflict of interest to disclose.

Acknowledgements

We would like to thank all the EMS personnel in Ishikawa Prefecture for their cooperation. TM and AY equally contributed to this article as the first authors.

References

1. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. Circulation 2001;104:2513-6.
2. Vaillancourt C, Verma A, Trickett J, et al. Evaluating the effectiveness of dispatch-assisted cardiopulmonary resuscitation instructions. Acad Emerg Med 2007;14:877-83.
3. Bohm K, Vaillancourt C, Charette ML, Dunford J, Castrén M. In patients with out-of-hospital cardiac arrest, does the provision of dispatch cardiopulmonary resuscitation instructions as opposed to no instructions improve outcome: A systematic review of the literature. Resuscitation 2011;82:1483-9.
4. Tanaka Y, Taniguchi J, Wato Y, Yoshida Y, Inaba H. The continuous quality improvement project for telephone-assisted instruction of cardiopulmonary resuscitation increased the incidence of bystander CPR and improved the outcomes of out-of-hospital cardiac arrests. Resuscitation 2012;83:1235-41.
5. Tanaka Y, Nishi T, Takase K, et al. Survey of a protocol to increase appropriate implementation of dispatcher-assisted cardiopulmonary resuscitation for out-of-hospital cardiac arrest. Circulation 2014;129:1751-60.
6. Hauff SR, Rea TD, Culley LL, et al. Factors impeding dispatcher-assisted telephone cardiopulmonary resuscitation. Ann Emerg Med 2003;42:731-7.
7. Kellermann AL, Hackman BB, Somes G. Dispatcher-assisted cardiopulmonary resuscitation. Validation of efficacy. Circulation 1989;80:1231-9.

8. Takei Y, Nishi T, Kamikura T, et al. Do early emergency calls before patient collapse improve survival after out-of-hospital cardiac arrest? Resuscitation 2015;88:20-7.

9. Calling the Emergency Call Service from a mobile phone: FAQs. Australian Communications and Media Authority, 2015. (Accessed 18 February 2016, at External link http://www.acma.gov.au/theACMA/calling-the-emergency-call-service-from-a-mobile-phone--faqs)

10. Kyoto Prefecture Police Headquarters. Dial 110 emergency call placed by mobile phone. Kyoto Prefecture Police, 2015. (Accessed 18 February 2016, at External link http://www.pref.kyoto.jp/fukei/foreign/tusi_c/110/mobile.html)

11. Strategies for future spectrum management in Japan. Ministry of Internal Affairs and Communications, Japan, 2007. (Accessed 18 February 2016, at External link http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/presentation/pdf/070713_1.pdf)

12. Kleinman ME, Brennan EE, Goldberger ZD, et al. Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary resuscitation and Emergency Cardiovascular Care. Circulation 2015;132:S414-35.

13. Perkins GD, Handley AJ, Koster RW, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. Resuscitation 2015;95:81-99.

14. Ministry of Education, Culture, Sports, Science and Technology. Ethical guidelines for epidemiological research. Ministry of Health, Labour and Welfare, Japan, 2002. (Accessed 18 February 2016, at External link http://www.niph.go.jp/wadai/ekigakurinri/guidelines.pdf)

15. Working Group of Japan resuscitation Council. JRC guidelines 2010. Japan Resuscitation Council, 2010. (Accessed 18 February 2016, at External link http://www.qqzaidan.jp/pdf_5/guideline1_BLS_kakutei.pdf)

16. Chamberlain D, Cummins RO, Abramson N, et al. Recommended Guidelines for uniform reporting of data from out-of-hospital cardiac arrest: the 'Utstein style': Prepared by a Task Force of Representatives from the European Resuscitation Council, American Heart Association, Heart and Stroke Foundation of Canada, Australian Resuscitation Council. Resuscitation 1991;22:1-29.

17. Jacobs I, Nadkarni V, Bahr J, the ILCOR Task Force on Cardiac Arrest and Cardiopulmonary Resuscitation Outcomes. Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update and Simplification of the Utstein Templates for Resuscitation Registries: a Statement for Healthcare Professionals from a Task Force of the International Liaison Committee on Resuscitation. Circulation 2004;110:3385–97.

18. Takei Y, Nishi T, Matsubara H, Hashimoto M, Inaba H. Factors associated with quality of bystander CPR: The presence of multiple rescuers and bystander-initiated CPR without instruction. Resuscitation 2014;85:492-8.

19. Nishi T, Maeda T, Takase K, et al. Does the number of rescuers affect the survival rate from out-of-hospital cardiac arrests? Two or more rescuers are not always better than one. Resuscitation 2013;84:154-61.

20. Takeuchi Y. Director of Space Communications Policy Division. Space Communications Policies in Japan. Ministry of Internal Affairs and Communications, Japan, 2006. (Accessed

18 February 2016, at External link http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/presentation/pdf/070713_1.pdf)

21. 5 Ways a Mobile Phone can save your life. REAL First Aid ltd, UK, 2015. (Accessed 18 February 2016, at External link http://www.realfirstaid.co.uk/mobile-phone/)

22. Working Group of the Resuscitation Council (UK). Adult basic life support and automated external defibrillation. Resuscitation Council (UK), 2015. (Accessed 18 February 2016, at External link https://www.resus.org.uk/resuscitation-guidelines/adult-basic-life-support-and-automated-external-defibrillation/#sequence)

23. Working Group of Resuscitation Council (UK). Guidelines 2010. Resuscitation Council (UK), 2010. (Accessed 18 February 2016, at External link https://www.resus.org.uk/archive/guidelines-2010/)

24. Birkenes TS, Myklebust H, Kramer-Johansen J. Time delays and capability of elderly to activate speaker function for continuous telephone CPR. Scand J Trauma Resusc Emerg Med. 2013;21:40.

25. Atkins DL, Berger S, Duff JP, et al. Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Cirlucation 2015;132:S519-25.

26. Kamikura T, Iwasaki H, Myojo Y, et al. Advantage of CPR-first over call-first actions for out-of-hospital cardiac arrests in nonelderly patients and on noncardiac aetiology. Resuscitation 2015;96:37-45.

27. Enami M, Takei Y, Inaba H, et al. Differential effects of ageing and BLS training experience on attitude towards basic life support. Resuscitation 2011;82:577-83.

28. Enami M, Takei Y, Goto Y, Ohta K, Inaba H. The effects of the new CPR guideline on attitude toward basic life support in Japan. Resuscitation 2010;81:562-7.

29. Ro YS, Shin SD, Song KJ, et al. Public awareness and self-efficacy of cardiopulmonary resuscitation in communities and outcomes of out-of-hospital cardiac arrest: A multi-level analysis. Resuscitation 2016;102:17-24.

Figure legends:

Figure 1: Overview of the study design.

Analysis of data related to dispatcher-assisted cardiopulmonary resuscitation begins from the top, and analysis of data pertaining to non-EMS-witnessed out-of-hospital cardiac arrest (OHCA) cases starts from the bottom.

Figure 2: Outcomes of non-EMS-witnessed OHCAs where emergency calls were made using mobile and landline phones.

Closed star symbols indicate significant difference by chi-square test or Fisher's exact probability test.

Figure 3: Multivariate logistic regression analysis for 1-month survival from non-EMS-witnessed OHCAs receiving BCPR.

Table 1

Table 1 Comparisons of DA-CPR- and BCPR-related parameters between mobile and landline phone calls

Parameters: definition and calculation	Emergency call		*P* value (chi-square test with Yates' correction)	Unadjusted OR (95% CI)
	Mobile phone	Landline phone		
Positive prediction value: (number of DA-CPR-attempted cases in cardiac arrest on EMS arrival at patients) / (number of all DA-CPR-attempted cases)	438/517 = 84.7%	1,594/2,013 = 79.2%	**<0.01**	**1.46 (1.12–1.90)**
Sensitivity: (number of DA-CPR-attempted cases in cardiac arrest on EMS arrival at patients) / [(number of all non-EMS-witnessed OHCA cases) – (number of cases receiving bystander-initiated BCPR without DA-CPR)]	438/(600-53) = 438/547 = 80.1%	1,594/(2380-296) = 1,594/2,084 =76.5%	0.08	1.24 (0.98–1.56)
The acceptance rate of DA-CPR: (Number of cases receiving BCPR following DA-CPR) / (number of DA-CPR-attempted cases in cardiac arrest on EMS arrival at patients)	353/438 = 80.6%	1,130/1,594 = 70.9%	**<0.01**	**1.71 (1.31–2.21)**
The degree of bystander's own performance of BCPR: (number of cases receiving bystander-initiated BCPR without DA-CPR) /[(number of all non-EMS-witnessed OHCA cases) –(number of DA-CPR-attempted cases in cardiac arrest on EMS arrival at patients)]	53/(600-438) = 53/162 = 32.7%	296/(2,380-1,594) = 296/786 = 37.7%	0.24	1.24 (0.87–1.78)

BCPR, bystander cardiopulmonary resuscitation; DA-CPR, dispatcher-assisted cardiopulmonary resuscitation; EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest; OR, odds ratio; 95% CI, 95% confidence interval

Table 2

Table 2 Differences in backgrounds and time factors of DA-CPR between mobile and landline phone calls

Backgrounds and time factors	Emergency calls		*P* value by univariable analysis*	Unadjusted OR (95% CI) with landline as reference
	Mobile phone N=517	Landline phone N=2013		
Patient's backgrounds				
Age, year, median (IQR)	**74 (61–83)**	**81 (72–87)**	**<0.01**	**undetermined**
Sex: male, % (N)	55.1% (285)	56.6% (1,140)		0.94 (0.77–1.14)
Cardiac arrest on EMS arrival at patient, % (N)	**84.7% (438)**	**79.2% (1,594)**		**1.46 (1.12–1.90)**
Time factors, seconds, median (IQR)				
Call receipt–dispatch	**83 (36–129)**	**59 (39–84)**	**<0.01**	**undetermined**
Call receipt–DA-CPR	**92 (60–152)**	**78 (56–122)**	**<0.01**	**undetermined**
Call receipt–EMS arrival at patients	**432 (343–569)**	**419 (324–553)**	**0.08**	**undetermined**
Backgrounds of callers				
Third party or other locations	**3.1% (16)**	**19.7% (396)**	**<0.01**	**0.13 (0.08–0.22)**
Family or relatives	61.5% (318)	63.8% (1,285)	0.33	0.91 (0.74–1.10)
Aged (>60 years)	**20.3% (105)**	**30.1% (606)**	**<0.01**	**0.59 (0.47–0.75)**
Information obtained from caller				
Unknown respiration	**10.4% (54)**	**16.9% (341)**	**<0.01**	**0.57 (0.42–0.78)**
Unknown responsiveness	**5.4% (28)**	**8.2% (164)**	**0.04**	**0.65 (0.43-0.98)**

* Chi-square test with Yates' correction or Fisher's exact probability test for nominal variables, Mann-Whitney test for continuous variables

DA-CPR, dispatcher-assisted cardiopulmonary resuscitation; IQR, interquartile range; OR, odds ratio; 95% CI, 95% confidence interval

Table 3

Table 3 Differences in backgrounds and time factors of non-EMS-witnessed OHCA between mobile and landline emergency calls

Backgrounds and time factors	**Emergency calls**		*P* value	Unadjusted OR (95% CI) With landline as reference
	Mobile phone N=600	Landline phone N=2,380		
Backgrounds				
Patient's age, years, median (IQR)	**72 (58–82)**	**81 (71–87)**	**<0.01**	**undetermined**
Sex: male, % (N)	**62.8% (377)**	**56.9% (1,355)**	**<0.01**	**1.28 (1.06–1.54)**
Location: home, % (N)	**56.8% (341)**	**64.6% (1,538)**	**<0.01**	**0.72 (0.60–0.86)**
Bystander-witnessed, % (N)	41.8% (251)	42.7% (1,015)	0.72	0.97 (0.81–1.60)
Single rescuer, % (N)	68.3% (410)	71.6% (1,705)	0.11	0.85 (0.70–1.04)
Presumed cardiac aetiology, % (N)	**39.8% (239)**	**44.5% (1,059)**	**0.04**	**0.83 (0.69–0.99)**
Bystander: family or relative, % (N)	**55.7% (334)**	**60.3% (1,435)**	**0.04**	**0.83 (0.69–0.99)**
Emergency call beside the patients, % (N)	**52.7% (316)**	**17.2% (409)**	**<0.01**	**5.36 (4.42–6.50)**
Any BCPR, % (N)	**67.7% (406)**	**59.9% (1,426)**	**<0.01**	**1.40 (1.16–1.69)**
BCPR with good-quality, % (N)	**53.5% (321)**	**45.0% (1,071)**	**<0.01**	**1.41 (1.18–1.68)**
Conventional bystander CPR, % (N)	4.7% (28)	6.5% (155)	0.09	0.70 (046–1.06)
Shockable initial rhythm, % (N)	**10.3% (62)**	**6.1% (144)**	**<0.01**	**1.79 (1.31–2.45)**
Tracheal intubation, % (N)	**17.0% (102)**	**13.3% (317)**	**0.02**	**1.33 (1.04–1.70)**
Adrenalin administration, % (N)	42.2% (253)	39.6% (943)	0.26	1.11 (0.93–1.33)
Time factors, minutes, median (IQR)				
Witness/recognition–call	**2.5 (1.3–5.5)**	**2.7 (1.4–6.7)**	**<0.01**	**undetermined**
Call receipt–EMS arrival at patients	8.1 (6.4–10.3)	8.0 (6.4–10.3)	0.72	undetermined
Duration of transportation	**10.2 (6.7–14.7)**	**9.5 (6–13.8)**	**0.03**	**undetermined**

BCPR, bystander cardiopulmonary resuscitation; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; IQR, interquartile range; OHCA, out-of-hospital cardiac arrest; OR, odds ratio; 95% CI, 95% confidence interval

Figure 1

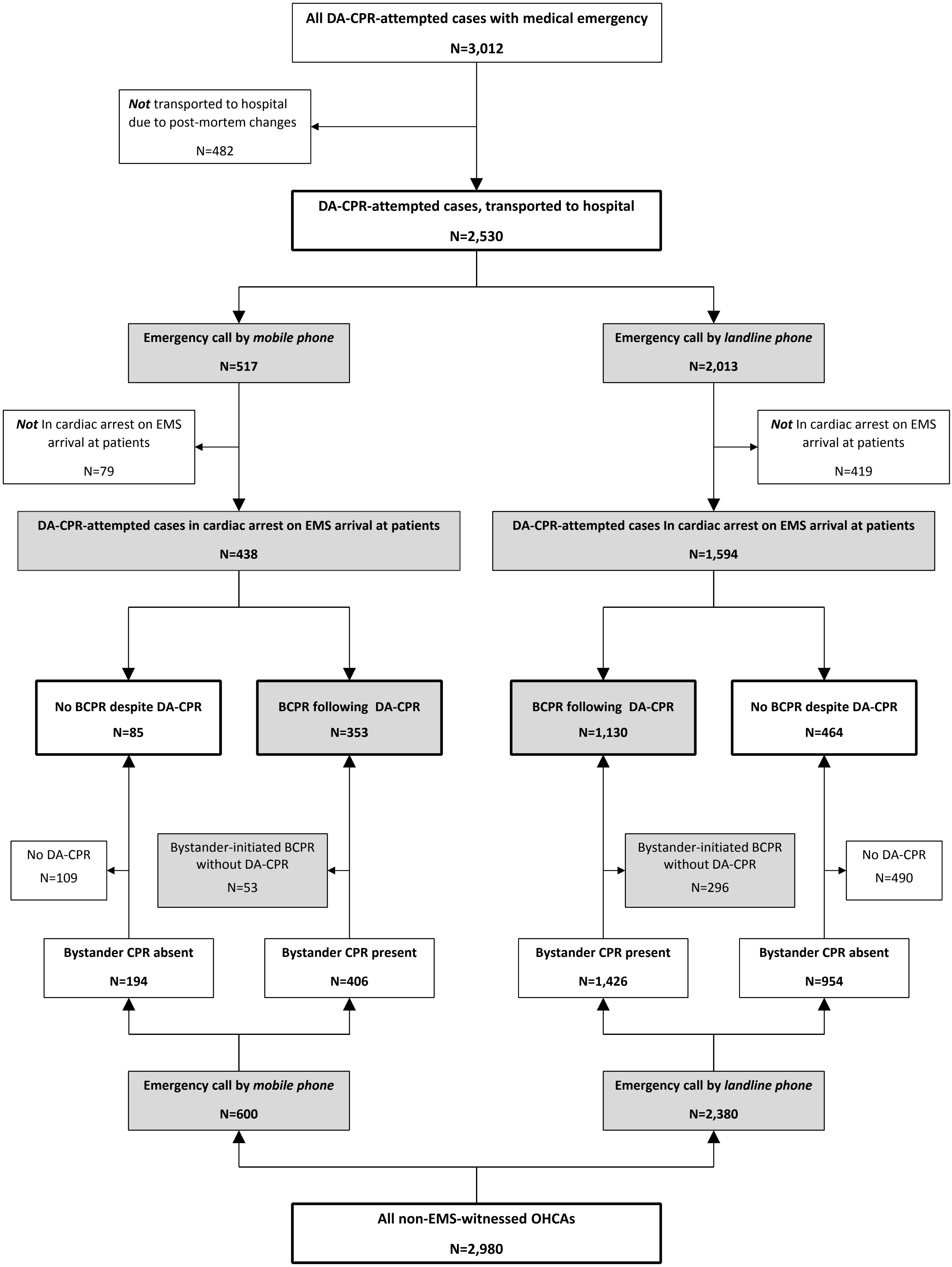

All DA-CPR-attempted cases with medical emergency
N=3,012
Not transported to hospital due to post-mortem changes
N=482
DA-CPR-attempted cases, transported to hospital
N=2,530
Emergency call by *mobile phone*
N=517
Emergency call by *landline phone*
N=2,013
Not In cardiac arrest on EMS arrival at patients
N=79
Not In cardiac arrest on EMS arrival at patients
N=419
DA-CPR-attempted cases in cardiac arrest on EMS arrival at patients
N=438
DA-CPR-attempted cases In cardiac arrest on EMS arrival at patients
N=1,594
No BCPR despite DA-CPR
N=85
BCPR following DA-CPR
N=353
BCPR following DA-CPR
N=1,130
No BCPR despite DA-CPR
N=464
No DA-CPR
N=109
Bystander-initiated BCPR without DA-CPR
N=53
Bystander-initiated BCPR without DA-CPR
N=296
No DA-CPR
N=490
Bystander CPR absent
N=194
Bystander CPR present
N=406
Bystander CPR present
N=1,426
Bystander CPR absent
N=954
Emergency call by *mobile phone*
N=600
Emergency call by *landline phone*
N=2,380
All non-EMS-witnessed OHCAs
N=2,980

Figure 2

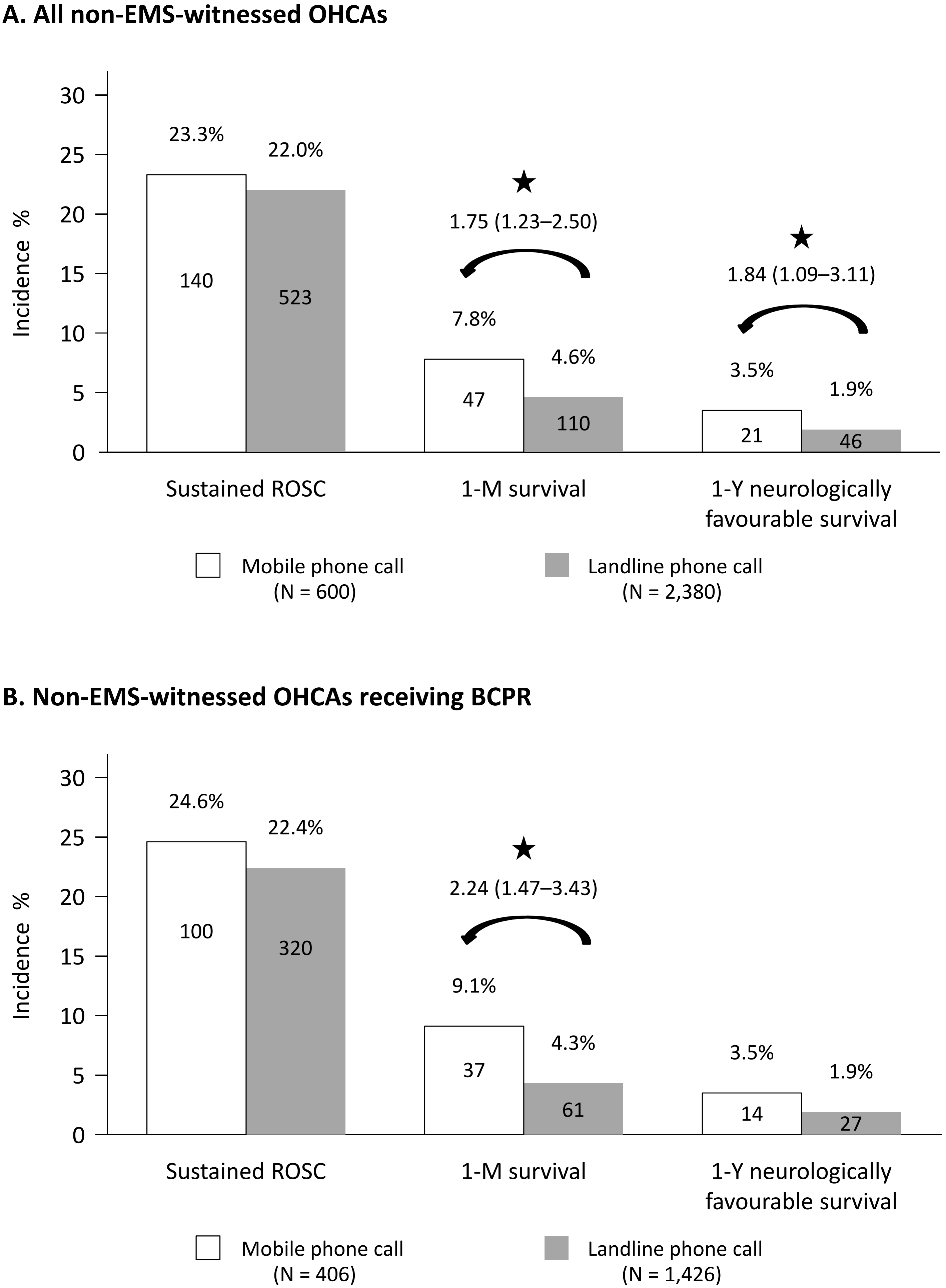
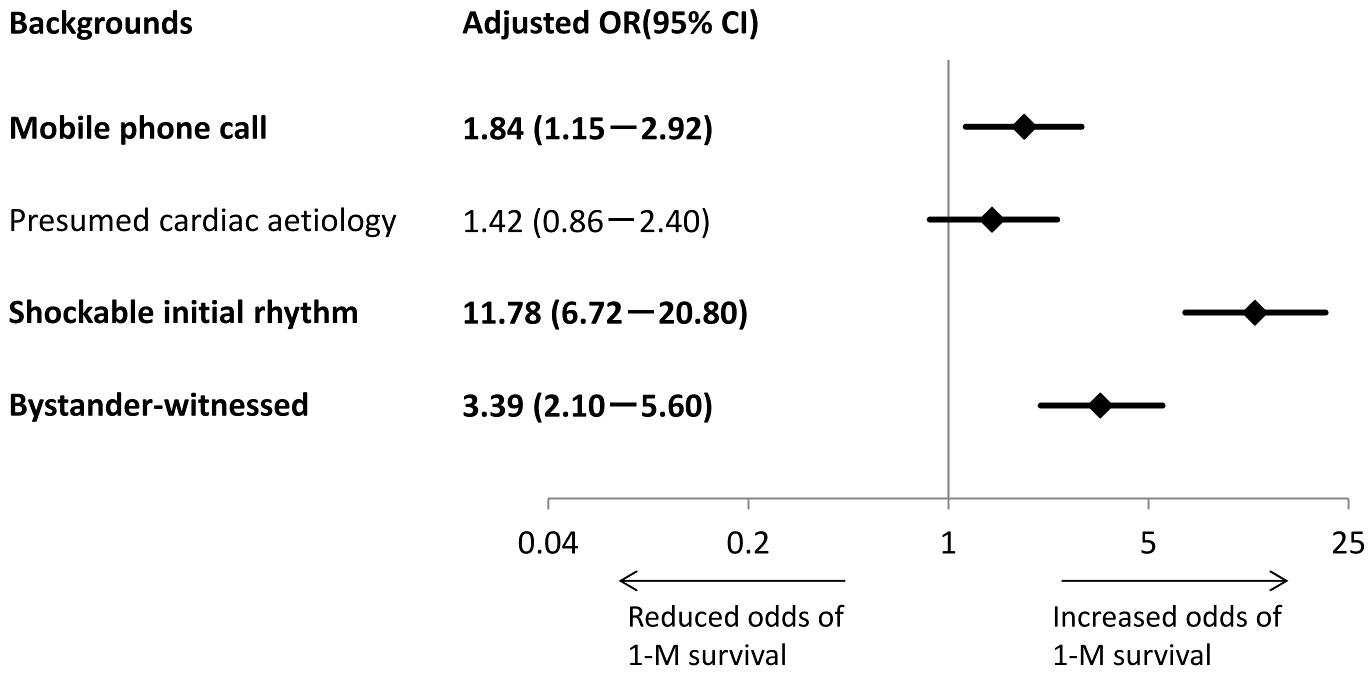

A. All non-EMS-witnessed OHCAs
Incidence %
30
25
20
15
10
5
0
23.3%
22.0%
140
523
1.75 (1.23–2.50)
7.8%
4.6%
47
110
1.84 (1.09–3.11)
3.5%
1.9%
21
46
Sustained ROSC
1-M survival
1-Y neurologically favourable survival
Mobile phone call (N = 600)
Landline phone call (N = 2,380)
B. Non-EMS-witnessed OHCAs receiving BCPR
Incidence %
30
25
20
15
10
5
0
24.6%
22.4%
100
320
2.24 (1.47–3.43)
9.1%
4.3%
37
61
3.5%
1.9%
14
27
Sustained ROSC
1-M survival
1-Y neurologically favourable survival
Mobile phone call (N = 406)
Landline phone call (N = 1,426)

Figure 3



Backgrounds
Adjusted OR(95% CI)
Mobile phone call
1.84 (1.15—2.92)
Presumed cardiac aetiology
1.42 (0.86—2.40)
Shockable initial rhythm
11.78 (6.72—20.80)
Bystander-witnessed
3.39 (2.10—5.60)
0.04
0.2
1
5
25
Reduced odds of
1-M survival
Increased odds of
1-M survival

Conflict of Interest Statement

The authors declare no conflict of interest to disclose.