Abnormal breathing of sudden cardiac arrest victims described by laypersons and its association with emergency medical service dispatcher-assisted cardiopulmonary resuscitation instruction

Hidetada Fukushima,1 Masami Imanishi,2 Taku Iwami,3 Tadahiko Seki,1 Yasuyuki Kawai,1 Kazunobu Norimoto,1 Yasuyuki Urisono,1 Michiaki Hata,1 Kenji Nishio,4 Keigo Saeki,5 Norio Kurumatani,5 Kazuo Okuchi1

ABSTRACT

Background: Current guidelines for cardiopulmonary resuscitation (CPR) emphasise that emergency medical service (EMS) dispatchers should identify sudden cardiac arrest (CA) with abnormal breathing and assist lay rescuers performing CPR. However, lay rescuers description of abnormal breathing may be inconsistent, and it is unclear how EMS dispatchers provide instruction for CPR based on the breathing status of the CA victims described by laypersons.

Methods and results: To investigate the incidence of abnormal breathing and the association between the EMS dispatcher-assisted CPR instruction and layperson CPR, we retrospectively analysed 283 witnessed CA cases whose information regarding breathing status of CA victims was available from population-based prospective cohort data. In 169 cases (59.7%), laypersons described that the CA victims were breathing in various ways, and that the victims were ‘not breathing’ in 114 cases (40.3%). Victims described as breathing in various ways were provided EMS dispatch-instruction for CPR less frequently than victims described as ‘not breathing’ (27.8% (47/169) vs 84.2% (96/114); p<0.001). Multivariate logistic regression showed that EMS dispatch-instruction for CPR was associated significantly with layperson CPR (adjusted OR, 11.0; 95% CI, 5.72 to 21.2).

Conclusions: This population-based study indicates that 60% of CA victims showed agonal respiration, which was described as breathing in various ways at the time of EMS call. Although EMS dispatch-instruction was associated significantly with an increase in layperson CPR, abnormal breathing was associated with a much lower rate of CPR instruction and, in turn, was related to the much lower rate of bystander CPR.

INTRODUCTION

Sudden cardiac arrest (CA) is a leading cause of death in the industrialised world. Approximately 300 000 CAs in the USA and 100 000 in Japan occur annually in out-of-hospital settings. The vast majority of these victims do not survive.1 2 Rapid initiation of cardiopulmonary resuscitation (CPR) for CA victims can increase the chance of survival without neurological deficits.3 4 However, the incidence of layperson CPR is low.4 2 Emergency medical service (EMS) dispatchers play a key role in the performance of CPR prior to the arrival of EMS personnel on the scene.4 5 EMS dispatchers can help laypersons identify CA and assist in the performance of CPR. However, the identification of CA victims with agonal respiration via telephone may be extremely difficult6 8 and EMS dispatcher-assisted CPR instruction is underused.7 9 To increase EMS dispatcher-assisted CPR instruction, we examined the actions of regional EMS dispatchers based on the description of sudden CA victims by laypersons. Although several studies have investigated the accuracy of CA recognition by EMS dispatchers,9 10 we identified only two population-based studies of laypersons’ descriptions of agonal respiration and its association with EMS dispatcher-assisted CPR instruction.6 11

In this study, we investigate laypersons’ descriptions of the respiratory condition in CA victims by use of a population-based registry of out-of-hospital cardiac arrest (OHCA). Furthermore, we assessed how EMS dispatch-instruction for CPR and breathing status of the CA victims described by laypersons were associated with CPR by lay rescuers.

MATERIALS AND METHODS

We conducted a retrospective analysis of prospective cohort data of all OHCA cases aged 18 years or older in whom resuscitation was attempted and who were then transported to medical institutions from 1 January 2007 through 31 December 2009. We included OHCA cases that were witnessed by a layperson. OHCA cases that collapsed after emergency call were excluded from this analysis. This study was approved by the ethical committee of Nara Medical University.

The population of Nara Prefecture is approximately 1.4 million inhabitants in an area of around 3700 km². Nara Prefecture has 13 fire stations with dispatch centres. The free emergency telephone number, 119, is used to call for an ambulance. All EMS dispatchers are trained firefighters. Each fire station had their own dispatch protocols for CA based on 2005 CPR guidelines. To identify CA victims, EMS dispatchers asked 119 callers whether the unresponsive victim was breathing. When the caller answered that the victim was breathing, EMS dispatchers asked how the victim was breathing and considered the possibility of agonal respiration. Once CA was suspected, the dispatchers instructed the caller to perform chest compressions or...
conventional CPR. Dispatchers did not ask laypersons to check the pulse of the victims.

Data were prospectively collected by use of a form based on the Utstein-style reporting guidelines for OHCA, including age, sex, origin of CA, location of arrest, disabilities in daily living, EMS dispatcher-assisted CPR instruction, bystander-initiated CPR, first documented rhythm, time course of resuscitation, advanced airway management, intravenous fluids and epinephrine, as well as prehospital return of spontaneous circulation, 1-month survival and neurological status at 1 month after the event. Both chest compression-only CPR and conventional CPR with rescue breathing were considered as layperson CPR. Rescue breathing without chest compression was classified as no CPR. The outcome was assessed by the health style according to the Glasgow–Pittsburgh overall performance category (OPC) at 1 month after the event. Good neurological outcome was defined as OPC 1 or 2.

Along with those Utstein data, we collected information regarding how laypersons described the breathing styles of CA victims. We collected the data from the anonymous written reports of emergency calls composed by each EMS dispatcher who actually took the emergency calls. EMS dispatchers asked for the callers for details of the victims’ responsiveness and breathing status routinely and recorded it on the report form.

Data were presented as medians and IQRs for continuous variables and numbers and percentages for categorical variables. Groups were compared using Mann–Whitney U test and χ² test. Multiple logistic regression analysis assessed the factors associated with layperson-performance of CPR; adjusted ORs (AORs) and their 95% CIs were calculated. Potential confounding factors that were biologically essential or significantly associated with layperson-performance of CPR at p<0.1 in the univariate analyses were considered in the multivariate analyses. All statistical analyses were two-sided and performed using computer software (SPSS V.19, Illinois, USA). The results were considered to be statistically significant at a p value less than 0.05.

RESULTS

During the 3-year period, EMS attempted resuscitation in 3173 OHCA cases. Of those, 735 cases met our inclusion criteria. Among these cases, layperson CPR was started before EMS calls in 76 cases. In the remaining 659 cases, information of breathing styles was not available in 376 cases, because the callers were upset, excited or separated from the victims. Therefore, we investigated 283 cases with no CPR by laypersons at the time of EMS call and with information on breathing styles (figure 1). Baseline characteristics of study subjects are described in table 1. The characteristics of the included 283 cases and excluded 376 cases were similar, although victims with information on breathing styles at the time of EMS-arrival time increased. Our data indicate the incidence of agonal respiration is much greater than expected in the early phase of out-of-hospital settings where lay rescuers face sudden CA and strongly supports the current 2010 guideline for CPR emphasising the importance of dispatchers to help lay rescuers recognise agonal respiration and start CPR.

DISCUSSION

This study revealed that lay rescuers described as much as 60% of CA victims were exhibiting various types of breathing at their EMS call, and that EMS dispatcher-assisted CPR instruction can increase layperson CPR. The combination of a population-based Utstein style registry and detailed reports regarding breathing style of sudden CA victims allows the evaluation of the effectiveness of EMS dispatch instruction to increase CPR by laypersons considering the impact of rescuers’ recognition of CA.

Our results suggest that the majority of CA victims showed abnormal breathing at the time of the EMS call. Since we excluded unwitnessed CA cases and victims who collapsed after EMS calls from all EMS resuscitation attempted CAs, these descriptions were considered to be agonal respiration. Bobrow et al. reported that the presence of agonal respiration was 33% in victims arrested after EMS arrival, and that its incidence decreased as collapse–EMS-arrival time increased. Our data indicate the incidence of agonal respiration is much greater than expected in the early phase of out-of-hospital settings where lay rescuers face sudden CA and strongly supports the current 2010 guideline for CPR emphasising the importance of dispatchers to help lay rescuers recognise agonal respiration and start CPR.

Table 3 shows the AORs and their 95% CIs for layperson CPR. EMS dispatcher-assisted CPR instruction (AOR; 11.0, 95% CI 5.72 to 21.2) and disabilities in daily living (AOR; 2.57, 95% CI 1.10 to 5.99) were significantly associated with the increment of layperson CPR.

Figure 1 Study population. CPR, cardiopulmonary resuscitation; EMS, emergency medical service.

<table>
<thead>
<tr>
<th>EMS resuscitation attempted (N=3173)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &lt; 18 years-old (N=86)</td>
</tr>
<tr>
<td>Cardiac arrest due to trauma, drowning, hanging, airway obstruction, and poisoning (N=894)</td>
</tr>
<tr>
<td>Not witnessed (N=1072)</td>
</tr>
<tr>
<td>Witnessed by health care providers or witnessed after EMS call (N=386)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Layperson witnessed cardiac arrest (N=735)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bystander CPR has already started before EMS call (N=76)</td>
</tr>
<tr>
<td>Cardiac arrest without Bystander at EMS call (N=659)</td>
</tr>
<tr>
<td>Lack of information on breathing styles because callers were upset, excited, or apart from the victims (N=376)</td>
</tr>
</tbody>
</table>

Information on breathing style at first call available (N=283)
many CA victims with agonal respirations might lose CPR instruction by the EMS dispatchers. Along with previous cases of those with possible agonal respiration described as abnormal breathing was associated with a much lower rate of lay rescuers to perform CPR presupposing an overdiagnosis of CA should be considered.

Multivariate analysis demonstrated that EMS dispatcher instruction for CPR was significantly associated with an increase in layperson CPR. However, this study also demonstrated that abnormal breathing was associated with a much lower rate of CPR instruction and, in turn, was related to a much lower rate of bystander CPR. These findings, along with the data regarding breathing status in sudden CA victims described by laypersons, emphasise the role of EMS dispatchers to identify CA victims with possible agonal respiration via telephone for improving the chain of survival.

LIMITATIONS
There are inherent limitations in this study.

First, over half of the eligible patients were excluded from the study because there was no information about breathing status. The callers who could report the victims’ breathing status might be acting more calm than callers in the excluded group and there might be a bias in laypersons’ descriptions of breathing status. This is a substantial limitation. However, because EMS dispatchers were required to ask and record the victims’ responsiveness and breathing status from the callers routinely, this low proportion of cases with complete information on breathing status suggests that it is usual for the callers to be upset, excited...
or separated from the victims and indicates difficulties for res-
cuers and dispatchers that need to be addressed in order to
develop dispatch-instructions.

Second, although we excluded the cases that a layperson wit-
nessed CA after the call, due to the nature of prehospital CA
study, we cannot deny the possibility to include victims not yet
in CA before EMS arrival.

Third, since data of the abnormal breathing described by lay-
persons were derived from documents of CA written by each
EMS dispatcher who actually took the emergency calls, some
recall biases might exist.

Finally, since we investigated a small numbers of study sub-
jects, the power to detect possibilities of possible agonal respira-
tion with clinical outcomes such as return of spontaneous
circulation or hospital admission and survival is quite limited.

CONCLUSION
This population-based study revealed that 60% of CA victims
had agonal respiration at the time of EMS call and lay rescuers’
descriptions on breathing status were varied. Although EMS
dispatch-instruction was associated significantly with an increase
in layperson CPR, abnormal breathing was associated with a
much lower rate of CPR instruction and, in turn, was related to
a much lower rate of bystander CPR. These results indicate that
EMS dispatchers should be more assertive for those CA victims
with possible agonal respiration.

Acknowledgements We thank Fire Head Offices in Nara prefecture for provision
of study information.

Contributors HF, MI, TS, YK and KN performed most of the data collection. KS and
NK performed statistical analysis of the collected data. HF, YU, MH, KN and TI
performed interpretation of the data. HF, TI and KO performed manuscript preparation.
All authors read and approved this version of the manuscript to be submitted.

Funding This study was supported by the Foundation for Ambulance Service
Development (Tokyo, Japan).

Competing interests None.

Ethics approval Ethical committee of Nara Medical University.

Provenance and peer review Not commissioned; externally peer reviewed.

Open Access This is an Open Access article distributed in accordance with the Creative
Commons Attribution Non Commercial (CC BY-NC 3.0) license, which permits others to
distribute, remix, adapt, build upon this work non-commercially, and license their
derivative works on different terms, provided the original work is properly cited and the
use is non-commercial. See: http://creativecommons.org/licenses/by-nc/3.0/.

REFERENCES
1 Nichol G, Thomas E, Callaway CW, et al. Regional variation in out-of-hospital
increased survival after out-of-hospital cardiac arrests: a large-scale
3 Holmberg M, Holmberg S, Herlitz J, et al. Survival after cardiac arrest outside
6 Bang A, Herlitz J, Martinek S. Interaction between emergency medical dispatcher
and caller in suspected out-of-hospital cardiac arrest calls with focus on agonal
breathing. A review of 100 tape recordings of true cardiac arrest cases.
7 Bohm K, Rosenqvist M, Hollenberg J, et al. Dispatcher-assisted telephone-guided
8 Bendovski J, Beekhuis F, Zwierseman AH, et al. Importance of the first link:
description and recognition of an out-of-hospital cardiac arrest in an emergency
9 Hauff SR, Rea TD, Culley LL, et al. Factors impeding dispatcher-assisted telephone
12 Cummins RO, Chamberlain DA, Abramson NS, et al. Recommended guidelines for
uniform reporting of data from out-of-hospital cardiac arrests: the Utstein Style.
Task Force of the American Heart Association, the European Resuscitation Council,
the Heart and Stroke Foundation of Canada, and the Australian Resuscitation Council.
13 Jacobs I, Naidakini V, Bahr J, et al. 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 (American Heart Association, European
Resuscitation Council, Australian Resuscitation Council, New Zealand Resuscitation
Council, Heart and Stroke Foundation of Canada, Interamerican Heart Foundation,
15 Kuisma M, Boyd J, Vayunny T, et al. Emergency call processing and survival from
16 Flynn J, Archer F, Morgans A. Sensitivity and specificity of the medical priority
dispatch system in detecting cardiac arrest emergency calls in Melbourne. Prehosp
17 Ma MH, Lu TC, Ng JC, et al. Evaluation of emergency medical dispatch in
patients, does the description of any specific symptoms to the emergency medical
dispatcher improve the accuracy of the diagnosis of cardiac arrest: a systematic
19 Hallstrom AP, Cobb LA, Johnson E, et al. Dispatcher assisted CPR: implementation
20 Roppolo LP, Westfall A, Pepe PE, et al. Dispatcher assessments for agonal breathing
21 Rea TD, Eisenberg MS, Culley LL, et al. Dispatcher-assisted cardiopulmonary
22 Bang A, Gustavsson M, Larsson C, et al. Are patients who are found deeply
unconscious, without having suffered a cardiac arrest, always breathing normally?
23 Coons SJ, Guy MC. Performing bystander CPR for sudden cardiac arrest: behavioral
24 White L, Rogers J, Bloomingdale M, et al. Dispatcher-assisted cardiopulmonary
25 Halsey KB, Lerner EB, Pirrallo RG, et al. The frequency and consequences of
cardiopulmonary resuscitation performed by bystanders on patients who are not in

Table 3 Variables associated with layperson CPR after EMS call

<table>
<thead>
<tr>
<th>Variables</th>
<th>Layperson CPR after EMS call (N=98)</th>
<th>Univariate analysis</th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
<th>Multivariate analysis</th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men, n (%)</td>
<td>64 (64.3)</td>
<td></td>
<td>1.20</td>
<td>0.73 to 1.99</td>
<td>0.48</td>
<td>1.24</td>
<td>0.67 to 2.28</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>Age &lt;75 years old, n (%)</td>
<td>46 (46.9)</td>
<td></td>
<td>1.16</td>
<td>0.71 to 1.90</td>
<td>0.55</td>
<td>1.85</td>
<td>0.99 to 3.43</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Victims with disabilities in daily living, n (%)</td>
<td>18 (18.4)</td>
<td></td>
<td>2.10</td>
<td>1.04 to 4.26</td>
<td>0.04</td>
<td>2.57</td>
<td>1.10 to 5.99</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Cardiac arrest at home, n (%)</td>
<td>87 (88.8)</td>
<td></td>
<td>0.85</td>
<td>0.39 to 1.89</td>
<td>0.69</td>
<td>0.50</td>
<td>0.19 to 1.31</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>EMS dispatcher-assisted CPR instruction, n (%)</td>
<td>81 (82.7)</td>
<td></td>
<td>9.45</td>
<td>5.16 to 17.3</td>
<td>&lt;0.001</td>
<td>11.0</td>
<td>5.72 to 21.2</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

CPR, cardiopulmonary resuscitation; EMS, emergency medical service.