Description of Abnormal Breathing Is Associated With Improved Outcomes and Delayed Telephone Cardiopulmonary Resuscitation Instructions

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Background—Emergency 9-1-1 callers use a wide range of terms to describe abnormal breathing in persons with out-of-hospital cardiac arrest (OHCA). These breathing descriptors can obstruct the telephone cardiopulmonary resuscitation (CPR) process.

Methods and Results—We conducted an observational study of emergency call audio recordings linked to confirmed OHCAs in a statewide Utstein-style database. Breathing descriptors fell into 1 of 8 groups (eg, gasping, snoring). We divided the study population into groups with and without descriptors for abnormal breathing to investigate the impact of these descriptors on patient outcomes and telephone CPR process. Callers used descriptors in 459 of 2411 cases (19.0%) between October 1, 2010, and December 31, 2014. Survival outcome was better when the caller used a breathing descriptor (19.6% versus 8.8%, $P<0.0001$), with an odds ratio of 1.63 (95% confidence interval, 1.17–2.25). After exclusions, 379 of 459 cases were eligible for process analysis. When callers described abnormal breathing, the rates of telecommunicator OHCA recognition, CPR instruction, and telephone CPR were lower than when callers did not use a breathing descriptor (79.7% versus 93.0%, $P<0.0001$; 65.4% versus 72.5%, $P=0.0078$; and 60.2% versus 66.9%, $P=0.0123$, respectively). The time interval between call receipt and OHCA recognition was longer when the caller used a breathing descriptor (118.5 versus 73.5 seconds, $P<0.0001$).

Conclusions—Descriptors of abnormal breathing are associated with improved outcomes but also with delays in the identification of OHCA. Familiarizing telecommunicators with these descriptors may improve the telephone CPR process including OHCA recognition for patients with increased probability of survival. **(*J Am Heart Assoc*. 2017;6:e005058. DOI: 10.1161/JAHA.116.005058.)**

Key Words: cardiac arrest • cardiopulmonary resuscitation • telecommunications

Out-of-hospital cardiac arrest (OHCA) is an enormous healthcare problem in industrialized countries.[1–3] More than 90% of OHCA patients die before reaching the hospital,[1] and survival rates remain disappointing even after hospital arrival.[4–6] Bystander cardiopulmonary resuscitation (BCPR) can more than double the chance of patient survival,[7] but BCPR rates remain between 30% and 40%[3,4] in most communities. Emergency medical telecommunicators play a key role in the period before arrival of emergency medical services.[8,9] Telephone CPR (TCPR), in which telecommunicators guide callers in performing CPR, can double the frequency of BCPR,[10] and recent guidelines emphasize the importance of TCPR for increasing rates and timeliness of BCPR.[11] Many factors, however, can obstruct recognition of OHCA. A prime factor that can prevent or delay recognition of cardiac arrest is abnormal breathing, which presents frequently in the early stages of OHCA.[12–17] Callers use various terms to describe this abnormal breathing.[13,17,18] These descriptors can confuse telecommunicators and prevent OHCA recognition.[17,19,20] In this population-based study, we evaluated patient outcomes when the caller used or did not use a breathing descriptor and audited OHCA audio recordings to identify the impact of caller descriptors of abnormal breathing on TCPR process measures.

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Accompanying Tables S1 and S2 are available at http://jaha.ahajournals.org/content/6/9/e005058/DC1/embed/inline-supplementary-material-1.pdf

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Clinical Perspective

What Is New?

- Our study found that abnormal breathing descriptions by emergency 9-1-1 callers are independently associated with delays in telephone cardiopulmonary resuscitation provision of up to 45 seconds, but these out-of-hospital cardiac arrest patients were more likely to survive with favorable functional outcome.

What Are the Clinical Implications?

- Our study emphasizes that early telecommunicator identification of abnormal breathing descriptions could help improve outcomes among persons experiencing out-of-hospital cardiac arrest.

Methods

Study Design and Population

We conducted an observational study of audio recordings from emergency 9-1-1 calls linked to confirmed OHCAs in an Utstein-style database between October 1, 2010, and December 31, 2014. The calls were received at 8 regional dispatch centers participating in the Save Hearts in Arizona Registry and Education (SHARE) program, a collaboration of the Arizona Department of Health Services, the University of Arizona, and fire departments, police departments, and hospitals statewide. This program and its results have been reported previously.[21–26] Because OHCA has been designated a major public health problem in Arizona and the objective of SHARE is to improve resuscitation quality and patient outcomes, the data collected were exempt from the Health Insurance Portability and Accountability Act requirements. The Arizona Department of Health Services' human subjects review board and the University of Arizona institutional review board approved publication of deidentified data.

The study population consisted of OHCAs of nontraumatic origin that were treated but not witnessed by emergency 9-1-1 responders. Audio recordings linked to these events were reviewed by program personnel according to a standardized process described previously.[27] The terms callers used to describe abnormal breathing were recorded in a structured database. We excluded cardiac arrests (1) if they occurred in nursing homes, doctor's offices, jails, or unknown locations, to focus on how non–healthcare professionals would describe abnormal breathing; (2) if CPR was not indicated in the recording, because SHARE personnel could not confirm that the patient was not conscious and not breathing or not breathing normally; (3) if a language barrier obstructed the dispatch process; or (4) if the caller was not with the patient. For the TCPR process analysis, we excluded calls in which (1) bystander CPR was started before telecommunicator instructions and (2) the audio was incomplete or fragmented.

The TCPR protocol in the dispatch centers specifies (1) compression-only CPR for adult arrests of presumed cardiac origin and (2) chest compression with rescue breathing for other causes of arrest. Emergency telecommunicators are expected to provide CPR instructions if the patient was reported as not conscious and not breathing normally. Roughly 80% of the audios investigated were from dispatch centers in Maricopa County that drafted their own protocols. The remainder were from dispatch centers outside Maricopa County using various versions of Medical Priority Dispatch or Association of Public Safety Communications Officials systems.

Measurements and Analysis

We divided the study population into 2 groups. The first group had at least 1 caller descriptor of abnormal breathing (Description YES group). The second group had no caller descriptors of abnormal breathing; the caller simply said the patient was "not breathing" or answered "no" when the telecommunicator asked if the patient was breathing normally (Description NO group). We investigated basic event characteristics such as patient age, sex, event location, witness status, BCPR status, shockable rhythm status, whether the patient had sustained return of spontaneous circulation, whether the patient survived, and whether the patient survived with good functional neurological outcome.

We considered TCPR to be provided if telecommunicators started CPR instructions that resulted in the start of bystander compressions. To determine whether caller descriptors effected TCPR process measures, we compared findings across 6 metrics between the 2 groups: (1) percentage of calls in which the telecommunicator recognized the need for TCPR, (2) percentage of calls in which the telecommunicator started TCPR instructions, (3) percentage of calls in which bystanders started TCPR, (4) time interval from call receipt until the telecommunicator recognized the need for TCPR, (5) interval from call receipt until the start of TCPR instructions, and (6) interval from call receipt until the bystander performed the first chest compression.

Statistical Analysis

Continuous variables were summarized by median and range and were compared between the 2 groups of patients using the Wilcoxon rank sum test. Categorical variables were summarized by frequency and proportion with 95% Clopper–Pearson confidence intervals (CIs) and were compared between the 2 groups by either χ^2 or Fisher exact test. The association between survival and description of abnormal breathing was also examined by logistic regression, adjusting for important risk adjusters and potential confounders including sex, age, location of arrest, presumed etiology of arrest, bystander-witnessed arrest, bystander CPR, shockable initial rhythm, and whether the patient was transported to a cardiac receiving center. The effect of the continuous variable age was fitted nonparametrically using penalized thin plate regression splines through the generalized additive model.[28] The backward elimination process was conducted to remove covariates from the model with a *P* value threshold of 0.05 while always keeping sex and age in the model. The process was then repeated to study the association between favorable functional outcome and description of abnormal breathing. In the process analysis, the proportions of calls with telecommunicator recognition of the need for TCPR, with TCPR instructions given or with TCPR started, were compared between the 2 groups of patients. To compare time to telecommunicator recognition of the need for TCPR, to start of TCPR instructions, and to first compression, the generalized log-rank test[29] was used to compare interval- and right-censored data. The software environment R[30] and the R packages interval[31] and Icens[32] were used for the time-to-event analysis. All tests were 2-sided with α=0.05. No adjustment for multiple testing was made.

Results

We reviewed 4298 audio recordings linked to OHCAs of nontraumatic origin that were treated but not witnessed by EMS. Among these, we excluded cases (1) at medical facilities, jails, or unknown locations (n=841); (2) in which CPR was not indicated (n=688); (3) with language barriers (n=57); and (4) in which callers were not with the patient (n=61). Overall, 2411 were eligible for the outcomes analysis (Description YES group, 459; Description NO group, 1952) and 1841 were eligible for the TCPR process analysis (Description YES group, 379; Description NO group, 1462;

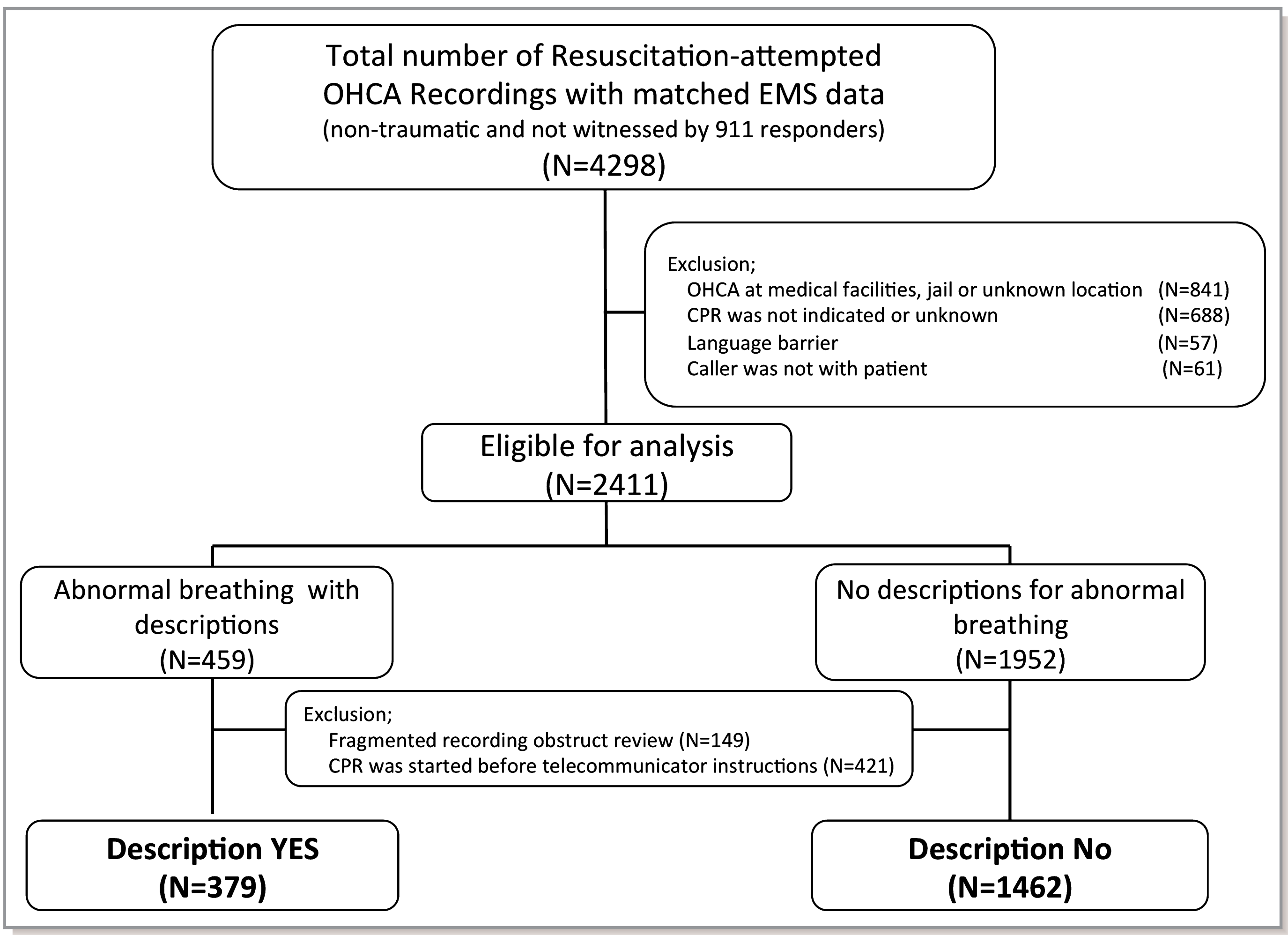

Figure 1. Overview of the study population. CPR indicates cardiopulmonary resuscitation; EMS, emergency medical services; OHCA, out-of-hospital cardiac arrest.

Table 1. Patient and Arrest Characteristics and Clinical Outcomes

Group	All (N=2411)	Description Yes (n=459)	Description No (n=1952)	*P* Value[†]
Sex				
Female	841 (34.9)	143 (31.2)	698 (35.8)	0.0707
Male	1570 (65.1)	316 (68.8)	1254 (64.2)	
Age, y	62 (0–101)	63.5 (0–97)	61 (0–101)	0.2972
Location of OHCA				
Residential	2136 (88.6)	393 (85.6)	1743 (89.3)	0.0319
Public	275 (11.4)	66 (14.4)	209 (10.7)	
Witnessed				
No	1642 (68.1)	233 (50.8)	1409 (72.2)	<0.0001
Yes	769 (31.9)	226 (49.2)	543 (27.8)	
Etiology				
Cardiac	2298 (95.3)	440 (95.9)	1858 (95.2)	0.0962
Drowning	28 (1.2)	1 (0.2)	27 (1.4)	
Drug/alcohol overdose	47 (1.9)	12 (2.6)	35 (1.8)	
Other noncardiac respiratory	3 (0.1)	1 (0.2)	2 (0.1)	
Respiratory	35 (1.5)	5 (1.1)	30 (1.5)	
Bystander CPR				
No	1068 (44.3)	226 (49.2)	842 (43.1)	0.0216
Yes	1330 (55.2)	231 (50.3)	1099 (56.3)	
Unknown	13 (0.5)	2 (0.4)	11 (0.6)	
Shockable initial rhythm				
No	1825 (75.7)	259 (56.4)	1566 (80.2)	<0.0001
Yes	566 (23.5)	193 (42)	373 (19.1)	
Unknown	20 (0.8)	7 (1.5)	13 (0.7)	
Intubated				
No	859 (35.6)	172 (37.5)	687 (35.2)	0.4252
Yes	1416 (58.7)	263 (57.3)	1153 (59.1)	
Unknown	136 (5.6)	24 (5.2)	112 (5.7)	
Sustained ROSC				
No	1898 (78.7)	316 (68.8)	1582 (81)	<0.0001
Yes	422 (17.5)	126 (27.5)	296 (15.2)	
Unknown	91 (3.8)	17 (3.7)	74 (3.8)	
Transported to CRC				
No	1009 (41.8)	154 (33.6)	855 (43.8)	0.0001
Yes	1401 (58.1)	305 (66.4)	1096 (56.1)	
Unknown	1 (0)	0 (0)	1 (0.1)	
Survival at discharge				
No	2085 (86.5)	353 (76.9)	1732 (88.7)	<0.0001
Yes	262 (10.9)	90 (19.6)	172 (8.8)	
Unknown	64 (2.7)	16 (3.5)	48 (2.5)	

Continued

Table 1. Continued

Group	All (N=2411)	Description Yes (n=459)	Description No (n=1952)	*P* Value†
CPC at discharge				
Low	177 (7.3)	68 (14.8)	109 (5.6)	<0.0001
High	2149 (89.1)	370 (80.6)	1779 (91.1)	
Unknown	85 (3.5)	21 (4.6)	64 (3.3)	

Median (minimum–maximum) for continuous variables and count (percentage) for categorical variables. All above information was from the emergency medical services database recorded in Utstein style. CPC indicates cerebral performance category; CPR, cardiopulmonary resuscitation; CRC, cardiac receiving center; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation.
†Fisher exact test or χ^2 test for categorical variables and Wilcoxon rank sum test for continuous variables; the unknown category, if present, is excluded from the testing procedure.

Figure 1). A summary of OHCA characteristics along with clinical outcomes in the 2 groups is shown in Table 1. The proportions of men in each group were not significantly different in the Description YES and NO groups (68.8% versus 64.2%, respectively; *P*=0.071). The 2 groups had similar age profiles, with a median of 62 years and range from 0 to 101 years in the combined sample. Patients in the YES group were more likely to be in a public location (14.4% versus 10.7%, *P*=0.032) and to have a witnessed arrest (49.2% versus 27.8%, *P*<0.0001) but were less likely to receive BCPR (50.3% versus 56.3%, *P*=0.022). Patients in the YES group were more likely to have a shockable initial rhythm (42% versus 19.1%, *P*<0.0001); to achieve sustained return of spontaneous circulation (27.5% versus 15.2%, *P*<0.0001); to be transported to a cardiac receiving center[26] that could provide therapeutic hypothermia, prompt percutaneous coronary interventions, and other guideline-based postarrest critical care (66.4% versus 56.1%, *P*=0.0001); to survive to discharge (19.6% versus 8.8%, *P*<0.0001); and to have favorable functional outcomes (14.8% versus 5.6%, *P*<0.0001). The logistic regression model analysis showed that the unadjusted odds ratio for description of abnormal breathing was 2.59 (95% CI, 1.95–3.46; *P*<0.0001) for the survival outcome and 3.06 (95% CI, 2.19–4.28; *P*<0.0001) for the favorable functional outcome (data are not shown). The adjusted odds ratio for description of abnormal breathing was 1.63 (95% CI, 1.17–2.25; *P*=0.003) for the survival outcome and 1.68 (95% CI, 1.15–2.46; *P*=0.008) for the favorable neurological outcome (Table. 2).

Figure 2 shows the frequencies of the 8 most common descriptors of abnormal breathing. The 3 categories with highest proportions were "gasping" (32%; 95% CI, 27.8–36.5),

Table 2. Fitted Logistic Regression Models for Survival and Favorable Functional Outcome

Variable	Levels	Survival OR (95% CI)	Survival *P* Value	Favorable Functional Outcome OR (95% CI)	Favorable Functional Outcome *P* Value
Description of abnormal breathing	No	1 (Reference)	0.003	1 (Reference)	0.008
	Yes	1.63 (1.17–2.25)		1.68 (1.15–2.46)	
Sex	Female	1 (Reference)	0.467	1 (Reference)	0.781
	Male	0.89 (0.65–1.22)		1.06 (0.70–1.60)	
Age		Nonparametric	<0.0001	Nonparametric	0.029
Location of arrest	Residential	Not included in the model		1 (Reference)	0.027
	Public			1.63 (1.06, 2.52)	
Bystander-witnessed arrest	No	1 (Reference)	<0.0001	1 (Reference)	0.0001
	Yes	2.74 (2.01–3.72)		2.19 (1.50–3.21)	
Bystander CPR performed	No	1 (Reference)	0.005	1 (Reference)	0.049
	Yes	1.57 (1.15–2.14)		1.48 (1.00–2.19)	
Shockable initial rhythm	No	1 (Reference)	<0.0001	1 (Reference)	<0.0001
	Yes	5.92 (4.32–8.12)		9.59 (6.33–14.53)	

CI indicates confidence interval; CPR, cardiopulmonary resuscitation; OR, odds ratio.

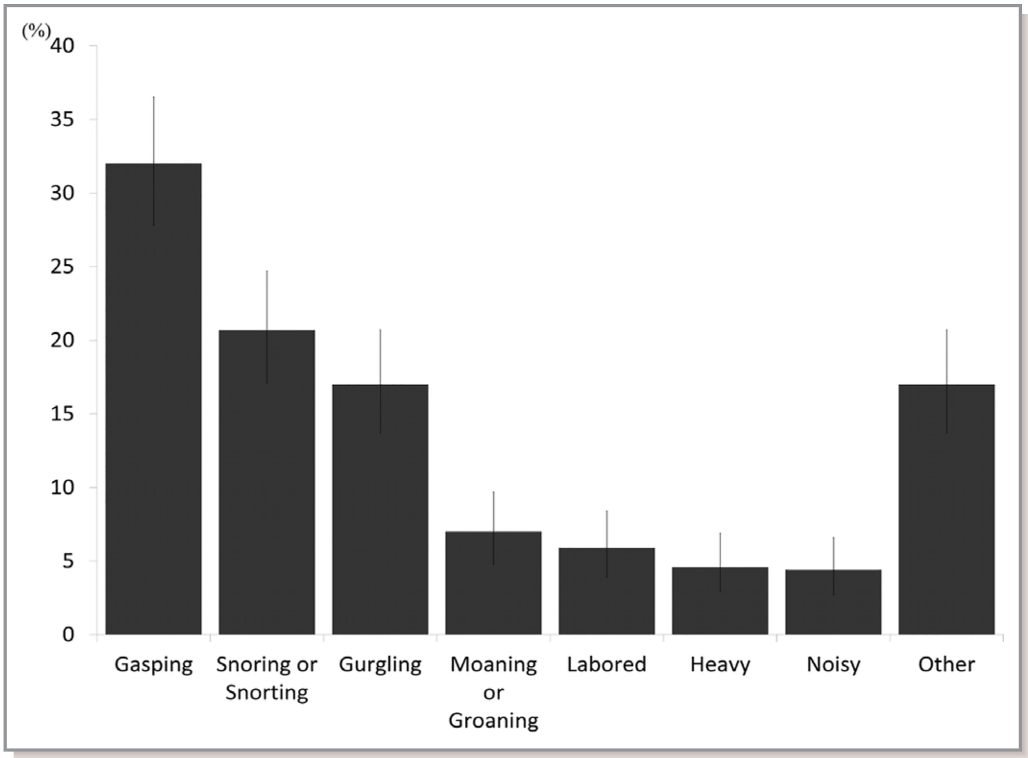

Figure 2. The variations and frequencies of emergency 9-1-1 callers' descriptions of abnormal breathing. Error bars indicate 95% confidence intervals. Because some callers described abnormal breathing with ≥2 terms, the total numbers of frequencies were 498. Others group was composed of minor descriptors: *wheezing, gagging, grunting, death rattle, deep, shallow, faintly, little, sporadically, slowly*, or *barely breathing*.

"snoring" or "snorting" (20.7%; 95% CI, 17.1–24.7) and "gurgling" (17%; 95% CI, 13.7–20.7). These were followed by "moaning" or "groaning," "labored," "heavy," and "noisy," each of which occurred in frequency <10%.

Results of the process analysis are shown in Tables 3 and 4. Table 3 summarizes the proportion of cases with each of 3 process events: (1) The telecommunicator recognized the OHCA, (2) CPR instructions were started, and (3) bystander chest compressions were started. The rate of OHCA recognition was lower in the YES group (79.7% versus 93.0%, $P<0.0001$), as were the rates of CPR instructions started and chest compressions started (65.4% versus 72.5% [$P=0.0078$] and 60.2% versus 66.9% [$P=0.0123$], respectively). The time between call receipt and OHCA recognition was longer in the YES group (118.5 versus 73.5 seconds, $P<0.0001$), as were the times to start of CPR instructions (203.5 versus 155.5 seconds, $P<0.0001$) and to start of chest compressions (242 versus 197.5 seconds, $P<0.0005$). A sensitivity analysis excluding cases in which callers could not get patients into position for CPR, had difficult access to patients, were in a dangerous environment, were severely distressed, refused CPR instructions, hung up or left the phone, were physically unable to do CPR, or thought the patient was dead demonstrated significant intergroup differences across all process measures and thus was consistent with the main process analysis (Tables S1 and S2).

Discussion

The Description YES group comprised 19% of eligible calls. Callers used various terms to describe abnormal breathing. The terms "gasping," "snoring," or "snorting," and "gurgling" accounted for roughly 70% of cases with descriptions. Consistent with previous studies' findings of improved survival among patients with agonal breathing, we found that patients for whom abnormal breathing was described had a higher chance of survival[13,15] than patients for whom it was not described. They also had a higher chance of favorable functional outcome. The rate of OHCA recognition was lower in the YES group and may in part explain the reduced proportion of cases in which CPR instructions and bystander compressions were started in this group. In addition, the time to OHCA recognition was 45 seconds longer in the YES group (118.5 versus 73.5 seconds, $P<0.0001$). This may in part explain the longer time to start of compressions in this group.

Table 3. Process Analysis: Proportion of Patients With Certain Events

Group	Description YES (n=379)	Description NO (n=1462)	*P* Value†
Telecommunicator knows CPR indicated			
No	75 (19.8)	84 (5.7)	<0.0001
Yes	302 (79.7)	1359 (93)	
Unknown	2 (0.5)	19 (1.3)	
CPR instructions started			
No	131 (34.6)	401 (27.4)	0.0078
Yes	248 (65.4)	1060 (72.5)	
Unknown	0 (0)	1 (0.1)	
CPR instructions started and compression started			
No	149 (39.3)	471 (32.2)	0.0123
Yes	228 (60.2)	978 (66.9)	
Unknown	2 (0.5)	13 (0.9)	

Count (percentage) for categorical variables. CPR indicates cardiopulmonary resuscitation.
†Fisher exact test or χ^2 test; the unknown category, if present, is excluded from the testing procedure.

These findings are collective evidence that abnormal breathing descriptions can be a barrier to optimal patient outcomes. To overcome this barrier, telecommunicators need to be familiar with the ways in which callers describe abnormal breathing in OHCA patients. Education and training that highlight these descriptions could shorten the time to OHCA identification, increase TCPR provision, and enhance outcomes for patients with abnormal breathing.

A study that reviewed OHCA dispatch recordings in the United States showed that "barely breathing" was the most frequent description, followed by "heavy or labored breathing" and "problems in breathing."[13] However, this study evaluated a small number of cases, and 2 other studies of caller descriptions were non–English-language reports.[17,18]

It was reported that these callers' descriptions for abnormal breathing can interfere with the TCPR process because callers tend to perceive abnormal breathing as a sign of life.[17,18] Hauff et al reviewed 404 OHCA audio recordings and reported that the TCPR process was impeded in 51 cases in which callers described signs of life such as "breathing." Even if telecommunicators identify cardiac arrest when callers describe abnormal breathing, the whole TCPR process can be obstructed.[22] Our study adds to previous work in quantifying the time to recognition for cases in which callers described abnormal breathing. Because the probability for survival decreases by roughly 7% to 10% every minute BCPR is not performed,[33] the 45-second delay in recognition reported can

Table 4. Process Analysis: Time to Events

Group	Description YES (n=379)	Description NO (n=1462)	*P* Value†
Time to telecommunicator's recognition of CPR (s)	118.5	73.5	<0.0001
Time to start of CPR instructions (s)	203.5	155.5	<0.0001
Time to first compression (s)	242	197.5	<0.0001

Estimated median in each group. CPR indicates cardiopulmonary resuscitation.
†Asymptotic logrank 2-sample test (permutation form) based on Sun scores.

be of great consequence in the period before arrival of emergency medical services.

Although the presence of descriptions appears to obstruct OHCA recognition, education and training on caller descriptors could turn these obstacles into opportunities to identify OHCA more quickly and comprehensively. Detailed regional analyses of callers' descriptions for abnormal breathing can be applied to local training and education to enhance the provision of TCPR across communities. Further studies across populations can help identify any universal descriptors that could be linked to survival and favorable functional outcomes of persons experiencing sudden cardiac arrest.

This study has limitations. First, we excluded 841 cases occurring in medical facilities, jails, and unknown locations in an effort to limit our catalog to terms lay rescuers use to describe abnormal breathing. Ultimately, however, the characteristics of emergency 9-1-1 callers are extremely difficult to assess, and we cannot rule out the possibility that some callers had medical backgrounds. Second, descriptions of abnormal breathing and their impact on telecommunicator instruction for CPR will vary by language and culture from one region to another; therefore, the applicability of our results to other countries and emergency medical services systems is unknown. Third, other unidentified barriers could also have affected our TCPR process measurements. Fourth, the majority of emergency 9-1-1 calls were received at dispatch centers in Maricopa County that draft their own protocols. This may limit the degree to which we can generalize of our findings. Finally, despite using a structured evaluation technique and data format, evaluating the TCPR process is not an exact science and requires some level of subjectivity and interpretation.

Conclusions

In this statewide study, we found that the identification of cardiac arrest and the start of CPR can be obstructed when the caller used a breathing descriptor. Caller descriptions of abnormal breathing in OHCA patients are associated with improved survival and functional outcome. Familiarizing telecommunicators with the most common descriptors may enhance cardiac arrest recognition, shorten the time to starting CPR, and improve patient outcomes.

Disclosures

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SUPPLEMENTAL MATERIAL

Table S1. Analysis of Process Measures: Proportion of Subjects with Certain Events. 796 additional cases were excluded from the main analysis because (1) callers couldn't get patients into position for CPR, (2) had difficult access to patients, (3) were in a dangerous environment, (4) were severely distressed, (5) refused CPR instructions, (6) hung up or left the phone, (7) were physically unable to do CPR or (8) thought the patient was dead. The results of this sensitivity analysis are below.

Group		Description YES[#] (N=253)	Description NO[#] (N=792)	p-value*
telecommunicator knows CPR indicated	No	69 (27.3%)	57 (7.2%)	< 0.0001
	Yes	183 (72.3%)	732 (92.4%)	
	Unknown	1 (0.4%)	3 (0.4%)	
CPR instructions started	No	84 (33.2%)	114 (14.4%)	< 0.0001
	Yes	169 (66.8%)	677 (85.5%)	
	Unknown	0 (0%)	1 (0.1%)	
CPR instructions started and compression started	No	84 (34.8%)	138 (17.4%)	< 0.0001
	Yes	163 (64.4%)	645 (81.4%)	
	Unknown	2 (0.8%)	9 (1.1%)	

Count (percentage) for categorical variables. *Fisher's exact test or Chi-squared test; the unknown category, if present, is excluded from the testing procedure. Abbreviations: CPR, cardiopulmonary resuscitation.

Table S2. Process Analysis: Time to Events after Excluding Cases With Barriers to TCPR

Group	Description YES[#] (N=253)	Description NO[#] (N=792)	p-value*
Time to telecommunicator's recognition of CPR (s)	132.5	72.5	< 0.0001
Time to start of CPR instructions (s)	173	116.5	< 0.0001
Time to first compression (s)	207	150.5	< 0.0001

Estimated median in each group. *Asymptotic logrank two-sample test (permutation form) based on Sun's scores. Abbreviations: CPR, cardiopulmonary resuscitation.