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Analysis of the Performance for Bystanders' Cardiopulmonary Resuscitation in Geriatric and Out-of-Hospital Cardiac Arrested Patients

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Background: The purpose of this study was to determine if there were changes in bystanders' chest compression performance and activation of emergency medical services in geriatric and out-of-hospital cardiac patients following the institution of the 2010 International Resuscitation Guidelines and 2008 Good Samaritan Law in South Korea. **Methods:** This is a retrospective observational study using medical records, and including patient charts and an Utstein Style database in a tertiary hospital. We analyzed the existence of chest compression performance by bystanders, the required time from recognition of cardiac arrest to activation of 119 for emergency medicine services, and the required time from activation of 119 to arrival on the scene from 2005-2014. The data were compared after dividing the years into 2 groups: 2005-2009 and 2010-2014. **Results:** Of 317 geriatric and out-of-hospital cardiac arrest patients, 261 were eligible for this study. Twelve cases were excluded, and a total of 249 were analyzed. Bystander-initiated chest compression was higher from 2010-2014 than from 2005-2009 (32 [20.13%] and 7 [7.78%], p=0.031, respectively). However, the time required from recognition of cardiac arrest to 119 activation and from 119 activation to arrival was not significantly different between the 2 groups (all p>0.05). **Conclusion:** It is possible that the release of the 2010 International Resuscitation Guidelines and the 2008 Good Samaritan Law may have influenced the potential incremental increase in chest compression performance by a bystander in geriatric and out-of-hospital cardiac arrest patients.

Key Words: Aged, Out-of-hospital cardiac arrest, Cardiopulmonary resuscitation, Bystander, Emergency medical services

INTRODUCTION

The average age of cardiac arrest patients in Korea was 61.17±19.6 years in 2013, with those aged 65 or older accounting for more than 50%[1]. The elderly population purportedly accounted for 13.1% of the total population in 2015 and is expected to reach 14.0% in 2017 and 20.8% in 2026, by which time the country is expected to become a super-aged society[2]. Considering this, the elderly would account for an increasing proportion of the total number of cardiac arrest patients.

Various studies on the survival rate of cardiac arrest patients reported that as the age of a cardiac arrest patient increased, the likelihood that he or she would survive after cardiopulmonary resuscitation (CPR) decreased[1,3,4], and Korea has a much lower survival rate than other advanced countries in this context[5]. Based on these low survival rates, several studies suggested that performing CPR on elderly cardiac arrest patients should cease[6-8]. However, other studies found that there was no difference in survival rate after CPR between elderly and nonelderly cardiac arrest patients[9-14].

In order to raise the survival rate of cardiac arrest patients, it is necessary to ensure that each goal in the chain of survival is successfully met, including swiftly identifying a cardiac arrest, activating the emergency response system, performing early CPR that emphasizes chest compressions, and applying rapid defibrillation[15-18]. To do this, bystanders' CPR and the swift arrival of emergency medical technicians or first responders would be critical before taking a patient to the hospital[19-22]. In Korea, the Good Samaritan Law was put in place in December 2008 to increase the rate of CPR

performance before hospital arrival, and provided legal protection to bystanders for the act of performing CPR[23]. In 2010, Korea provided CPR training on chest compressions that complied with newly established international guidelines published in 2010[24]. As a result of these efforts, data on cardiac arrest patients in Korea demonstrated that the chest compression performance rate of bystanders increased from 8%-10% in 2004 to 22.1% in 2013[1].

There has been no research in Korea regarding the length of time it takes bystanders to recognize cardiac arrest in elderly patients and report the situation to the emergency medical services system, or how frequently they performed CPR on site. In this regard, the authors aimed to examine whether there were changes in these parameters following 2010, the year when new CPR guidelines were announced and training and promotion were expanded for bystanders performing chest compressions in elderly people experiencing cardiac arrest; the activation of the emergency medical service system, and the time taken for the ambulance to arrive at the scene were also assessed.

MATERIALS AND METHODS

1. Study Subjects and Duration

This is a retrospective study based on medical records, which consist of charts and a cardiac arrest database. It was approved by the Institutional Review Board of the Hanyang University Hospital (HY2016-04-023) and was conducted in May 2016. The study subjects included patients ≥65 years of age who experienced cardiac arrest outside the hospital among patients admitted to the Emergency Medical Center of a tertiary university hospital in Seoul between January 1, 2005 and December 31, 2014. Patients excluded from study were those who had cardiac arrest while being transferred in an ambulance through 119 (a Korean emergency medical service), and those who refused CPR.

2. Study Methods

The cardiac arrest database followed the Utstein Style, an objective tool to access cardiac arrest patients published by American Heart Association (AHA) and European Resuscitation Council[25,26], and emergency medicine residents wrote the database based on patient history and 119 emergency activity records. Among other records made before hospital arrival, this study collected the location of cardiac arrest, whether cardiac arrest was witnessed, the time cardiac arrest was noticed or witnessed by bystanders, the time when it was reported to the emergency medical service system, the time when 119 first responders arrived at the scene, whether a bystander performed chest compressions or used the automated external defibrillator (AED) before 119 first responders arrived, the AED application by 119 first responders and the initial electrocardiogram (ECG) rhythm, and whether the patient had a return of spontaneous circulation (ROSC) before arriving at the Emergency Department. Among records made after hospital arrival, the study examined the estimated cause for cardiac arrest, whether the patient had an ROSC, and whether the patient was discharged from the hospital alive. A primary outcome variable was existence of chest compression performance by bystanders. Secondary outcome variables were recognition of cardiac arrest to 119 activation, which was the time it took bystanders to witness or discover cardiac arrest and report it to 119; 119 activation to arrival, which was the time it took first responders to arrive at the scene after the report; and recognition of cardiac arrest to 119 arrival, the total time required.

3. Data Analysis

The study used standard spreadsheet applications (Excel, Microsoft, Redmond, WA, USA) and PASW Statistics version 18.0 (SPSS Inc., Chicago, IL, USA) for data analysis. The study expressed categorical data through frequency and percentage (%) while regarding continuous data as following the normal distribution according to the central limit theorem, if the sample size was >30 and it was presented through mean and standard deviation and 95% confidence interval. Data were grouped into G 2005-9 (from 2005 to 2009) and G 2010-4 (from 2010 to 2014). This study used an independent t-test to compare continuous data of the 2 groups and a chi-square test or Fisher exact test to compare categorical data. The significance level of the statistics was set as $p<0.05$. In addition, descriptive statistics were conducted on the trend of each year from 2005 to 2014.

RESULTS

In the period of study from January 2005 to December 2014, the total number of patients admitted to the hospital for out-of-hospital cardiac arrest was 317. After excluding 30 patients who experienced cardiac arrest in an ambulance during the transfer and 26 patients who refused CPR, 261 were deemed appropriate for the study. Finally, 12 additional patients were excluded (4 whose data were lost, 3 whose records were omitted, and 5 who were lost in follow-up after discharge); hence, the study analyzed data of 249 patients (Fig. 1).

Regarding the characteristics of the 2 groups of patients, there was no difference in age, sex, place of cardiac arrest and cause of cardiac arrest, nor was there a significant difference found in the frequency of cardiac arrest witnesses, the rate of ROSC, and the rate of survival to discharge.

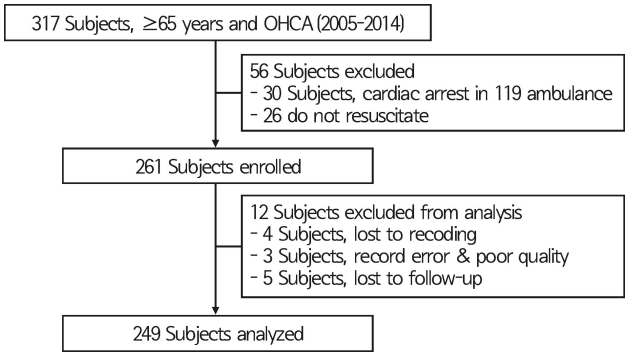

Fig. 1. Screening, enrollment, and analysis of subjects. OHCA, out-of-hospital cardiac arrest; CA, cardiac arrest.

For elderly cardiac arrest patients in particular, there were no bystanders who used AEDs during the period of study; that is, the AED was not used even once. According to the initial ECG rhythm at the scene between the two groups, it was found that the rhythm requiring defibrillation increased from G 2010-4 (7.8% vs. 20.8%, p<0.001) (Table 1). While there were 7 cases (7.78%) for the existence of chest compression performance of bystanders in G 2005-9, there were 32 cases (20.13%) in G 2010-4 that increased significantly (p=0.031). More importantly, when the location of cardiac arrest was inside the house, the chest compression performance rate of bystanders increased significantly (p=0.006), but there was

Table 1. Characteristics of patients in geriatrics (≥65 years) and OHCA between G 2005-9 and G 2010-4

Characteristic	G 2005-9 (n=90)	G 2010-4 (n=159)	p-value
Age (yr)	73.62±6.93	76.10±7.37	0.858
Male sex	53 (58.0)	102 (62.9)	0.411
Location of cardiac arrest			0.142
Home	60 (66.7)	115 (72.3)	
Workplace	0 (0.0)	2 (1.3)	
Public place	13 (14.4)	12 (7.5)	
Street	10 (11.1)	9 (5.7)	
Nursing home	5 (5.6)	11 (6.9)	
Other	2 (2.2)	10 (6.3)	
Etiology of cardiac arrest			0.460
Nontraumatic	75 (85.0)	137 (89.1)	
Cardiac	32 (32.0)	48 (27.4)	
Noncardiac	43 (53.0)	89 (61.7)	
Traumatic	15 (15.0)	22 (10.9)	
Application of AED by bystander	0 (0)	0 (0)	N/A
Activation of EMS	84 (93.3)	153 (96.2)	0.361
Initial rhythm on scene			<0.001*
Shockable†	7 (7.8)	33 (20.8)	
Nonshockable‡	11 (12.2)	58 (36.5)	
Not applied or unknown	72 (80.0)	68 (42.8)	
Whether or not of witness CA			0.631
Yes	56 (62.2)	94 (59.1)	
No	34 (37.8)	65 (40.9)	
Recovery of spontaneous circulation			0.925
Yes	27 (30.0)	51 (32.1)	
Before arrival in-hospital	2 (2.2)	4 (2.5)	
After arrival in-hospital	25 (27.8)	47 (29.6)	
No	63 (70.0)	108 (67.9)	
Survival discharge	3 (3.3)	8 (5.0)	0.812

Values are presented as mean±standard deviation or number (%).
Categorical variables were tested by chi-square test or Fisher exact test and continuous variables were calculated by independent t-test.
OHCA, out of hospital cardiac arrest; G 2005-9, 2005 to 2009 years; G 2010-4, 2010 to 2014 years; AED, automatic external defibrillator; EMS, emergency medical services; CA, cardiac arrest.
*p<0.05, statistically significant. †Ventricular fibrillation or pulseless ventricular tachycardia. ‡Asystole or pulseless electrical activity.

Table 2. Comparison of outcomes in OHCA and geriatric (≥65 years) patients between G 2005-9 and G 2010-4

Characteristic	G 2005-9 (n=90)	G 2010-4 (n=159)	p-value
Existence of chest compression performance by the bystander	7 (7.78)	32 (20.13)	0.031*
Recognition of cardiac arrest to 119 activation† (min)	5.65±14.11 (4.58-6.34)	4.41±11.39 (5.98-7.36)	0.427
119 Activation to arrival‡ (min)	5.46±4.28 (8.14-14.08)	6.67±4.40 (9.17-13.00)	0.239
Recognition of cardiac arrest to 119 arrival§ (min)	11.11±14.42 (2.74-8.55)	11.08±12.26 (2.64-6.20)	0.664

Values are presented as number (%) or mean±standard deviation (95% confidence interval).
Categorical variables were tested by chi-square test or Fisher exact test and continuous variables were calculated by independent t-test.
OHCA, out-of-hospital cardiac arrest; G 2005-9, 2005 to 2009 years; G 2010-4, 2010 to 2014 years.
*p<0.05, statistically significant. †Time interval from recognition of cardiac arrest to activation of 119 emergency medical service. ‡Time interval from activation of 119 emergency medical service to arrival of 119 at scene. §Time interval from recognition of cardiac arrest to arrival of 119 on scene.

Table 3. Comparison of outcomes in OHCA and geriatric (≥65 years) patients according to location of cardiac arrest between 2 groups

Place	Characteristic	G 2005-9	G 2010-4	p-value
Home	Existence of chest compression performance by the bystander	3 (5.00)	24 (20.87)	0.006*
	Recognition of cardiac arrest to 119 activation† (min)	6.88±18.09	5.18±14.04	0.493
	119 Activation to arrival‡ (min)	5.78±2.12	6.58±3.88	0.140
	Recognition of cardiac arrest to 119 arrival§ (min)	12.67±18.07	11.08±15.33	0.739
Public area	Existence of chest compression performance by the bystander	1 (7.69)	3 (25.00)	0.322
	Recognition of cardiac arrest to 119 activation† (min)	1.08±2.10	2.50±3.06	0.185
	119 Activation to arrival‡ (min)	19.38±8.68	16.83±2.86	0.343
	Recognition of cardiac arrest to 119 arrival§ (min)	21.46±7.14	19.33±4.83	0.396
Street	Existence of chest compression performance by the bystander	1 (10.00)	2 (22.22)	0.582
	Recognition of cardiac arrest to 119 activation† (min)	0.50±1.58	0.44±0.73	0.924
	119 Activation to arrival‡ (min)	4.20±2.30	8.22±7.64	0.130
	Recognition of cardiac arrest to 119 arrival§ (min)	4.70±2.54	9.44±8.44	0.138

Values are presented as number (%) or mean±standard deviation.
Categorical variables were tested by chi-square test or Fisher exact test and continuous variables were calculated by independent t-test.
OHCA, out of hospital cardiac arrest; G 2005-9, 2005 to 2009 years; G 2010-4, 2010 to 2014 years.
*p<0.05, statistically significant. †Time interval from recognition of cardiac arrest to activation of 119 emergency medical service. ‡Time interval from activation of 119 emergency medical service to arrival of 119 at scene. §Time interval from recognition of cardiac arrest to arrival of 119 on scene.

no difference in the rate in public places or on the street. Analysis of the time it took bystanders to recognize a cardiac arrest patient, report it to the emergency medical service system and have the ambulance arrive at the scene showed that there was no statistical difference between the 2 groups, regardless of the location of cardiac arrest (Tables 2, 3).

The frequency and percentage of chest compressions performed by bystanders after they witnessed or found an elderly patient experiencing cardiac arrest, the time it took to activate the emergency medical service system, and the time it took the ambulance to arrive at the scene are as follows (Table 4): the rate of chest compressions performed by bystanders increased annually from 2005 to 2014. In contrast, there was no annual decrease found in recognition of cardiac arrest to 119 arrival, the total time it took the ambulance to arrive at the scene after bystanders witnessed or found cardiac arrest. Even when it was divided into recognition of cardiac arrest to 119 activation and 119 activation to arrival, there was no annual decline.

DISCUSSION

In this study, the existence of CPR performance by the lay rescuer when an elderly patient had cardiac arrest increased significantly in G 2010-4, and for each year, it was on the rise from 0 case (0%) in 2005 to 10 cases (24.4%) in 2014. This change in performance rates is consistent with statistics on cardiac arrest patients of all ages in Seoul, including elderly patients[24,27]. The number of lay people educated about CPR for each 100,000 Seoul citizens rose each year, from 2,143 in 2010, while the number of people registered as citizens performing CPR on cardiac arrest patients with good faith (CPR supporters) reached 26,000[24]. This actual performance of CPR might have been affected by the growing

Table 4. Annual value of outcomes in OHCA and geriatrics (≥65 years) patients from years 2005 to 2014

Characteristic	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Cardiac arrest case (n)	17	16	19	23	15	21	24	31	42	41
Existence of chest compression performance by the bystander, n (%)	0 (0)	1 (6.3)	2 (10.5)	1 (4.3)	3 (20.0)	2 (9.5)	6 (25.0)	9 (29.0)	5 (11.9)	10 (24.4)
Mean recognition of cardiac arrest to 119 activation† (min)	8.76	4.60	5.07	3.96	4.94	2.80	5.83	2.65	5.79	4.12
Mean 119 activation to arrival‡ (min)	5.53	8.20	4.45	5.08	4.71	7.20	5.00	6.21	7.00	7.91
Mean recognition of cardiac arrest to 119 arrival§ (min)	14.29	12.80	10.85	9.04	9.65	10.00	10.83	8.85	12.79	12.03

OHCA, out of hospital cardiac arrest.
†Time interval from recognition of cardiac arrest to activation of 119 emergency medical service. ‡Time interval from activation of 119 emergency medical service to arrival of 119 at scene. §Time interval from recognition of cardiac arrest to arrival of 119 on scene.

awareness of ordinary people regarding the importance of CPR. The 2010 guidelines of the AHA recommended that lay people perform chest compressions only during CPR, which does not include mouth-to-mouth resuscitation[28,29]. In addition, telephone CPR was launched in 2012 in Seoul[24], where a 119 dispatcher guides lay people with performing CPR before first responders arrive at the scene. These methods such as training regarding simple and easy-to-perform CPR and telephone instructions might have contributed to an increase in chest compression performance. Compared to North Carolina, USA or Japan where the performance rate reached as much as 50%, the rate in Korea still remains quite low[30,31]. Since the most common place for an elderly patient to experience cardiac arrest is inside the home[1], training should be expanded to elementary school students and elderly people in consideration of the nuclear family and population aging, while repeated training should be provided to ensure that training remains effective.

Along with CPR performance of lay people, use of an AED is strongly associated with the survival of cardiac arrest patients[30,32,33]. In 2012, 2.3% of bystanders in Japan and 6.0% of bystanders in North Carolina in 2013 were reported to have used an AED[30,31]. Even though the number of AEDs for 100,000 people in Seoul had expanded from 0.3 in 2007 to 35.6 in 2014[24], in this study there was no case where bystanders used AEDs on elderly patients when they had cardiac arrest. While it is necessary to continue to provide AEDs, it is equally important to make them available in places where it is easy for bystanders to find them and provide training about how to use them. By contrast, analysis on the application of AED on elderly cardiac arrest patients after 119 first responders arrived showed that the percentage of AED use increased from 20% in G 2005-9 to 57.3% in G 2010-4, and the percentage of the rhythm requiring defibrillation increased from 7.8% (7 patients) in G 2005-9 to 20.8% (33 patients) in G 2010-4. This could have something to do with the fact that the proportion of first-grade first responders who could treat patients with professional CPR increased from 2.2% in 2006 to 4.7% in 2014, which led to more cases where AEDs were applied[24]. In addition, there could be many variables at play such as whether bystanders had witnessed cardiac arrest before, whether they had necessarily discovered a cardiac arrest patient, the underlying disease of a patient and bystanders' quality of performance of chest compressions[11-15].

AHA guidelines suggest swift activation of the emergency response system when there is no breath or reaction from a patient after bystander's discovery and assessment of the patient's consciousness[15]. Swift recognition of cardiac arrest and activation of the emergency medical service system would allow professional first responders to arrive at the scene faster, provide high quality CPR, and apply AED. In a Swedish study that analyzed 1,254 cardiac arrest records of emergency medical dispatchers, it took 1 minute (median) to recognize cardiac arrest, and it took lay people 3.67 minutes to begin CPR[34]. There has as yet been no report about recognition of cardiac arrest to 119 activation in Korea. In this study, there was no annual decline in the time it took from recognizing cardiac arrest to activating the emergency medical service system, nor was there a difference between the 2 groups. Furthermore, the time it took the ambulance to arrive at the scene did not decrease annually, and there was also no difference between the 2 groups in this regard. In order to reduce the time taken for the ambulance to arrive at the cardiac arrest patients, it is believed that more resources (e.g., personnel, facilities, and equipment) are needed to improve 119 emergency services. In addition, applying a system that categorizes the level of emergency and seriousness of cardiac arrest of patients would help to reduce the number of unnecessary services.

The limitations of the study are as follows. First, the study was conducted at a single institution, so it may not be repre-

sentative of the characteristics of all elderly cardiac arrest patients in Korea. Second, the study was not able to examine the basic characteristics of ordinary individuals who witnessed or found cardiac arrest patients such as whether they were trained about CPR beforehand and their level of performance. Third, factors that might have affected chest compression performance of bystanders such as mobile phones or telephone instructions were not taken into consideration. Fourth, regarding analysis of the time for the lay public to witness or find cardiac arrest patients and to activate the emergency medical service system, we used the time as recorded by emergency medicine specialists via personal interview instead of objectively checking a timepiece such as a watch or clock. The time denoted by bystanders who witnessed or found cardiac arrest patients could have been inaccurate based on their memory or perception. Lastly, the study was not able to examine the impact of the time taken for chest compression performance of bystanders and activation of the emergency medical service system on defibrillation rhythm, ROSC and the rate of survival to discharge.

The introduction of the Good Samaritan Law in 2008, a revision of AHA guidelines in 2010 and expanded training might have influenced an increase in chest compression performance of lay people upon witnessing or discovering cardiac arrest in the elderly. However, there was no effect on the time taken for activation of the emergency medical service system or the time taken for arrival of the ambulance.

Conflict of Interest Disclosures: The researchers claim no conflicts of interest.

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