Implementation of Gold Standard EMS CPR Programs for 2% Improvement in Survival Rates of Out-of-Hospital Cardiac Arrest in a Metropolitan City (2% Project)

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Study protocol

Study design and Setting

This study was a before and after study of the implementation of a bundle of UTIS CPR programs in Seoul Metropolitan City. The before phase was defined as January 2013 through December 2014 and included a historic control population. The after phase was defined as January 2015 through December 2016.

Seoul has approximately 10 million inhabitants per 605 km2. The SMFD provides fire-based and public service under 24 EMS agencies with 140 ambulances with a single unified dispatch center, with approximately 300,000 transports per year including 4,800 OHCAs. EMS providers can provide care comparable to an intermediate emergency medical technician (EMT-I) level in the United States. EMTs cannot declare death or stop CPR in the field unless a return of spontaneous circulation (ROSC) occurs. Therefore, all patients with OHCA are transported to emergency departments (EDs) while receiving CPR in an ambulance. The EMS CPR protocols were revised on the 2010 and 2015 International guidelines.

In Seoul, a DACPR program was implemented in 2010 and has been in effect for all calls suspected to involve cardiac arrest. The dispatch center has a standard protocol for DACPR with two steps; 1) screening potential OHCAs by primary call dispatcher (PCD) and 2) providing telephone CPR instruction by medical call dispatcher (MCD).Prior to 2015, Seoul was covered by a single-tiered EMS service to respond to OHCA events. A nearest and available ambulance was dispatched to an OHCA event. Of the 140 ambulances, only 27 (23.3%) were equipped with a defibrillator with a feedback function until December 2014. However, there was no active feedback CPR training as a feedback to EMTs after review of the CPR records by medical directors.

Intervention

A bundle of three UTIS CPR programs were implemented in Jan. 2015; 1) a high-quality DACPR program, 2) a rapid dispatch program using MTR, and 3) an FCPR program using defibrillators with feedback functions. A high-quality DACPR program was implemented in 2015 in addition routine DACPR program. This program included monthly monitoring and evaluation of the quality of the call

receiving and consulting stages by a medical director. Ten percent of the calls correctly identified as cardiac arrest and 10% of the calls not recognized as cardiac arrest were randomly selected based on the records from the ambulance run sheet. The audit reviews were performed in a standardized manner and recorded on an audio review evaluation sheet. Performance standard indicators were set, and feedback for the executive members, including the dispatch center officers and medical directors during the study period. Key performance standard indicators included OHCA detection rate by the PCD and proportion of calls given CPR instructions within 120 seconds. Monthly education conferences for dispatchers were conducted to get feedback of the performance standards per individual and per dispatch teams. The rapid CPR program included a multi-tier response (MTR) using the nearest available fire engine or basic life support vehicle team in addition to routine ambulance dispatch. An MTR scene protocol was developed, and a train-the-trainer model was used to disseminate the protocol. Six education programs were conducted, and 141 (10.8% of all the EMS providers in Seoul) participants from 24 EMS agencies were trained as trainers in 2015. They conducted MTR CPR training programs for all the EMTs and firefighters in Seoul. The FCPR program included the distribution of defibrillators with feedback functions to each ambulance and EMT training program; EMS personnel were also strongly encouraged to use a defibrillator with a feedback function for professional recording of EMS-CPR, and the medical director provided feedback to the individual teams using these defibrillators. All CPR processes were recorded by these devices and uploaded by the EMTs after CPR to an electronic server of the SMFD to be reviewed by the EMS medical directors. The MTR was a newly implemented program, but the other two programs were incomplete before 2015. It is a new attempt in this study to try to apply both programs (DACPR and FCPR) robustly and systematically to the whole city EMS.

Data sources and collection

We used the Korean OHCA Registry of by the Korea Centers for Disease Control and Prevention (CDC), which captures all incident cases of OHCA in the Seoul, was retrieved from the following four sources: the EMS run sheets for basic ambulance operation information, the EMS CPR registry, the dispatcher CPR registry, and the hospital OHCA registry for hospital care and outcomes. The medical record reviewers from the Korea CDC extracted the recorded information on the cause of arrest, hospital care

and outcomes from approximately 700 hospitals. To ensure the quality of the medical record review process, a quality management committee of emergency physicians, epidemiologists, statistical experts, and medical record review experts analyzed the data every month while providing feedback to each medical record reviewer.

Study population

Patients with OHCA of presumed cardiac etiology who were 15 years of age or older and who used the EMS system in Seoul between January 2013 and December 2016 were included. Patients were excluded from the analysis if they did not receive resuscitative attempts, had their episode witnessed by EMS providers, or occurred at a primary care clinic or long-term care facility. Patients with missing information on neurologic outcomes at the time of discharge were also excluded.

Main outcomes

The primary outcome was good neurologic recovery at discharge from the hospital, which was defined as having a cerebral performance categories (CPC) score of 1 or 2. The secondary outcome was survival to hospital discharge. The tertiary outcome was the prehospital return of spontaneous circulation (ROSC). The reviewers who were employed at the Korea CDC visited approximately 700 hospitals and extracted the final treatment results using the medical records of the doctors and nurses and the final discharge summary.

Variables and measurement

Bystander CPR was categorized into the following 3 groups: bystander CPR with dispatcher assistance group, bystander CPR without dispatcher assistance group, and no bystander CPR group. The MTR was positive if more than 2 vehicles arrived to cases with the same accident number. There were two types of MTR including an ambulance-tiered response (ATR) and a fire-engine-tiered response (FTR). FCPR was considered as positive if the corresponding ambulance used a defibrillator with feedback function. We collected following variables 1) demographics (age, gender, past medical history (diabetes mellitus, hypertension, heart disease, and stroke), event date and time (season, weekend, daytime)), 2)

community factors (location of arrest (public vs. private vs. other), witness status, primary cardiac rhythm at the scene (shockable, PEA and asystole), and bystander CPR or defibrillation), 3) EMS factors (EMS defibrillation, prehospital advanced airway, fluid resuscitation, mechanical CPR device use, detection time interval from call to detection of OHCA by the dispatcher, and EMS time intervals (response time interval, scene time interval, and transport time interval), and 4) post-resuscitative care (cardiac reperfusion therapy, targeted temperature management, and extracorporeal membrane oxygenation (ECMO)).

Sample size calculation

There were not enough previous studies available to determine the sample size needed to evaluate the effectiveness of the Utstein CPR program bundle. Prior to the initiation of the study, the sample size was estimated assuming a survival rate of 9% during the control period and an 11% survival rate during the experimental period. For each group of patients, 4,035 were needed to assess significant differences based on 80% of power and 0.05 of alpha.

Statistical analysis

The demographic findings and survival outcomes of the study population by study period are compared. The continuous variables were compared using the Wilcoxon rank sum test and the categorical variables were compared using the chi-squared test. The temporal trends by study period with six-month interval on performance indicators for each intervention were evaluated by the Cochran-Armitage test for the trends. We calculated the absolute differences (AD) with 95% confidence intervals (CIs) of the outcomes between the study periods and between the patient groups receiving each CPR program. A mixed-effects logistic regression model using the GLIMMIX procedure was used to estimate the association between the study period with outcomes, adjusting for the following: demographics (Model 1); demographics, community factors, and EMS factors (Model 2); demographics, community factors and EMS factors, and post-resuscitation care factors (Model 3); and finally, demographics, community factors and EMS factors, ACLS factors, and post-resuscitation care factors (Model 4) Outcomes were compared to assess the overall effect of all programs administered to patients before and after intervention. To assess the

individual effects of each program, a multi-variable logistic regression analysis was performed to evaluate the association between individual programs and outcomes. We constructed a mixed-effects logistic regression model to test the association between each CPR program (DACPR, MTR, and FCPR) and outcomes that was adjusted for potential confounders. We included random intercepts for ambulance station to control for clustering within the ambulance stations in both models. The effect sizes were calculated with AOR and 95% CIs. The p value was set at 0.05, and all statistical tests were 2-tailed. All statistical analyses were performed using the SAS version 9.4 software (SAS Institute Inc., Cary, NC, USA) and R version 3.4.1 (available at https://www.rproject.org. accessed on Feb. 25, 2018).