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Clinical paper

Impact of bystander-performed ventilation on functional outcomes after cardiac arrest and factors associated with ventilation-only cardiopulmonary resuscitation: A large observational study☆

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ABSTRACT

Aim: To determine the effectiveness of ventilations in bystander cardiopulmonary resuscitation (BCPR) and to identify the factors associated with ventilation-only BCPR.
Methods: From out-of-hospital cardiac arrest (OHCA) data prospectively collected from 2005 to 2011 in Japan, we extracted data for 210,134 bystander-witnessed OHCAs with complete datasets but no prehospital involvement of physician [no BCPR, 115,733; ventilation-only, 2093; compression-only, 61,075; and conventional (compressions+ventilations) BCPR, 31,233] and determined the factors associated with 1-month neurologically favourable survival using simple and multivariable logistic regression analyses. In 91,885 patients with known BCPR durations, we determined the factors associated with ventilation-only BCPR.
Results: The rate of survival in the no BCPR, ventilation-only, compression-only and conventional group was 2.8%, 3.9%, 4.5% and 5.0%, respectively. After adjustment for other factors associated with outcomes, the survival rate in the ventilation-only group was higher than that in the no BCPR group (adjusted OR; 95% CI, 1.29; 1.01–1.63), but lower than that in the compression-only (0.76; 0.59–0.96) or conventional groups (0.70; 0.55–0.89). Conventional CPR had the highest OR for survival in almost all OHCA subgroups. The adjusted OR (95% CI) for survival after dividing BCPR into ventilation and compression components was 1.19 (1.11–1.27) and 1.60 (1.51–1.69), respectively. Older guidelines, female sex, younger patient age, bystander-initiated CPR without instruction, early BCPR and short BCPR duration were associated with ventilation-only BCPR.
Conclusions: Ventilation is a significant component of BCPR, but alone is less effective than compression in improving neurologically favourable survival after OHCAs.

1. Introduction

Emergency medical technicians (EMTs) report the case of out-of-hospital cardiac arrest (OHCA), in which bystanders have performed ventilation-only cardiopulmonary resuscitation (CPR) in victims of EMT-confirmed OHCA. This rare ventilation-only bystander CPR (BCPR) has been believed to be ineffective, and simply grouped as no BCPR or excluded from analysis.[1–4] Consequently, neither the effects of ventilation-only BCPR on bystander-witnessed OHCA outcomes nor the factors associated with ventilation-only BCPR have been studied in a population-based cohort. Conventional CPR is a combination of ventilations and chest compressions. In order to clarify the effectiveness of ventilations, analysis is required for both the additive and independent effects of ventilations.

Since the International Liaison Committee on Resuscitation (ILCOR) and American Heart Association (AHA) Guideline released

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in 2000,[5] the requirement for laypersons or bystanders to check for a pulse was removed form CPR assessment. Since the ILCOR Consensus 2005[6] and related guidelines,[7,8] bystanders may initiate chest compressions with or without ventilation in adults who are unresponsive and breathing abnormally. Therefore, most cased with respiratory arrest receive compression-only or conventional (compressions+ventilations) CPR.[9]

In infants and children, respiratory arrest is more common than cardiac arrest, and ventilations are considered extremely important in paediatrics resuscitation.[5–7,10–12] Similarly, ventilations have been believed to be beneficial in some adult OHCAs of non-cardiac aetiology, including asphyxia, trauma and submersion.[4–7,13]

In the present study, we aimed to determine the effectiveness of ventilation in BCPR for bystander-witnessed OHCAs. In addition, we elucidated the factors associated with ventilation-only BCPR.

2. Methods

2.1. Study design and setting

We obtained the consent of the Japanese Fire and Disaster Management Agency (FDMA) to analyze the OHCA data prospectively collected between 2005 and 2011. The study group comprising members of the Ishikawa Medical Control Council (MCC) and their collaborators designed this study, which was approved by the review board of Ishikawa MCC.

Japan has a population of 128 million, of which over 20% are older than 65 years. In 2012, 791 fire departments had 4965 ambulance teams.[14] EMTs must not terminate resuscitation at the scene unless an OHCA patient is obviously dead or presents post-mortem changes. Paramedics may use airway adjuncts, including suprapharyngeal devices and may commence a peripheral venous infusion on Ringer's lactate. However, only authorized and specially trained paramedics are permitted to insert tracheal tubes and to administer intravenous adrenaline to adult OHCA victims.

At the end of 2006, the Japan Resuscitation Council (JRC) announced similar guidelines[15] to those of the AHA.[10] Prior to these, citizens were educated according to the ILCOR/AHA Guidelines 2000.[5] Therefore, citizens were substantially trained for basic life support (BLS) in accordance to newer guidelines in the period of 2007–2011 and older guidelines in the period of 2005–2006.

2.2. Data selection

We analyzed the FDMA database of 797,422 OHCAs that occurred from January 2005 to December 2011. First, we extracted a dataset comprising 217,969 bystander-witnessed OHCA without any prehospital involvement of physicians due to the following reasons; (1) some of these cases received prehospital advanced life support (ALS) performed by physicians on duty,[16] (2) these physicians on duty played primary roles in the treatment and transportation of patients, (3) according to the Utstein Recommendations,[17,18] these physicians on duty should not be categorized as a bystander. Then, we excluded the following cases lacking the essential information for analysis; 160 cases in which the relationship of the bystander to the victim was unknown and 2753 cases in which the provision of dispatcher-assisted CPR (DA-CPR) was unknown. Finally, we selected 210,134 bystander-witnessed cases with a complete dataset available (Fig. 1). In these OHCA cases, we determined whether ventilation-only BCPR was as ineffective as no BCPR and whether it was less effective than compression-only or conventional BCPR. Also, we determined the effectiveness of ventilations and compressions as individual BCPR components in an alternative analysis. Furthermore, we performed subgroup analysis for presumed cardiac or non-cardiac OHCAs and for paediatric (<20 years) or adult (≥20 years) OHCAs. For the factors associated with ventilation-only BCPR, we analyzed 91,885 BCPR cases with known BCPR durations.

2.3. Methods of measurement

FDMA databases include the following information recommended at the Utstein International Conference[18,19]: patient backgrounds, arrest witness, aetiology of OHCA (presumed cardiac or non-cardiac), type of BCPR (ventilation-only, compression-only or conventional), origin of BCPR (with or without DA-CPR instruction), initial cardiac rhythm, estimated time of collapse (obtained from the interviews to bystanders), time of bystander and EMT CPR initiation and EMT arrival, 1-month (1-M) survival, bystander group (family members and others) and 1-M cerebral performance category.[19,20] The time points of collapse and BCPR initiation were determined by EMT's interview with the bystander. Cardiac or non-cardiac origin was clinically determined by the physicians in collaboration with EMTs. Fire departments obtained information on 1-M survivals from hospitals.

2.4. Outcome

The primary outcome was the 1-M neurologically favourable survival (cerebral performance category, 1 or 2) in the main part of this study. Ventilation-only BCPR was the primary outcome in another part of this study.

2.5. Statistical analysis

Data were analyzed using JMP version 11 Pro (SAS institute, Cary, NC) and/or a computer software by Preacher.[21] Differences across groups for nominal variables were assessed using the χ^2 test with and without Yates' correction and the assessments were confirmed by Fisher's exact test. The Kruskal–Wallis test was first applied for nonparametric comparisons of continuous variables. Simple logit analysis was first applied for component analysis of ventilation and compression.

Multivariable logistic regression analysis was employed to confirm the association of the BCPR type or BCPR components with the 1-M neurologically favourable survival and to identify the factors associated with ventilation-only BCPR. For the two 1-M neurologically favourable survival models, we sequentially introduced groups of variables into the model: first, basic variables known to be definitively associated with OHCA outcomes (arrest aetiology, initial rhythm and call – EMS arrival at patients interval), then variables identified as significant in univariate analysis (patient age, patient sex, prehospital tracheal intubation, adrenaline administration, guidelines, bystander–patient relationship, witness – call interval and EMS arrival at patients – EMS arrival at hospital interval) in a stepwise manner to obtain the lowest Bayesian information criterion (BIC). For the ventilation-only CPR model, we first applied multivariable logistic regression analysis for the factors that were significant in univariate analysis, before adding the factors that were not significant in a stepwise manner to obtain the lowest BIC. The root mean square error (RMSE, Appendix A) and Generalized R^2 (GR^2, Appendix B) of the final model were computed to measure the fit of the regression model. For each analysis, the null hypothesis was evaluated at a 2-sided significant level of $p < 0.05$; with 95% CI calculated using profile likelihood.