Resuscitation 102 (2016) 80–84

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Prognostication of out-of-hospital cardiac arrest patients by 3-min end-tidal capnometry level in emergency department☆

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ARTICLE INFO

Article history:
Received 2 December 2015
Received in revised form 9 February 2016
Accepted 24 February 2016

Keywords:
Asystole
Resuscitation
End-tidal capnography
Casualty, Prognosis

ABSTRACT

Objective: To evaluate the role of initial $ETCO_2$ value in prognostication of OHCA patients in an Asian-Chinese cohort.
Design: Prospective cohort study.
Setting: Emergency departments of two regional hospitals in a cluster of Hong Kong.
Patients: Patients were recruited prospectively from the local cardiac arrest registry from July 2012 to June 2013. Patients of non traumatic OHCA aged ≥18 years old were included. Patients of OHCA presented with postmortem changes, those who decided for Do Not Resuscitate (DNR), regained pulse before arrival, or those without proper documentation of $ETCO_2$ would be excluded.
Outcome: Primary outcome was return of spontaneous circulation (ROSC).
Results: A 3-min $ETCO_2$ >10 mmHg was a predictor of ROSC with OR 18.16 (95% CI 4.79–51.32, $p < 0.001$). The diagnostic accuracy of 3-min $ETCO_2$ >10 mmHg to predict ROSC: sensitivity was 0.95 (95% CI 0.89–0.98) while the specificity was 0.27 (95% CI 0.21–0.33). Positive predictive value was 0.40 (95% CI 0.34–0.46) while negative predictive value (NPV) was 0.92 (95% CI 0.82–0.97). Area under ROC curve of 3-min $ETCO_2$ predicting ROSC was 0.80 (95% CI 0.71–0.91).
Conclusions: A 3-min $ETCO_2$ ≤10 mmHg was associated with poor prognosis and low chance of ROSC. Low $ETCO_2$ level may have a role to reduce prolonged medically futile resuscitation.

Introduction

End-tidal CO_2 capnometry ($ETCO_2$) is recommended to be used in ACLS 2010 guideline. It not only helps to monitor the effectiveness of chest compression in resuscitation where its value being less than 10–15 mmHg indicated that there was insufficient effort,[1–3] but also helps to indicate the return of spontaneous circulation (ROSC) when there is an abrupt and sustained rise of $ETCO_2$ >40 mmHg.[4–5] There was increasing evidence that low level $ETCO_2$ being less than 10 mmHg was associated with poor prognosis and prediction of death.[6–7] Identifying prognosticators of out-of-hospital cardiac arrest (OHCA) at emergency department based on readily available bedside parameters, including $ETCO_2$ values, was essential to reduce prolonged medical futile resuscitation. We aim to evaluate the role of 3-min $ETCO_2$ value in prognostication of OHCA patients in an Asian-Chinese cohort.

Methods

Study design and setting

This is a prospective cohort study performed in two regional hospitals in a cluster of Hong Kong which served a population of over one million. All cardiac arrest patients occurred in the area were delivered by the emergency medical services (EMS) to these two receiving hospitals. The study period was from July 2012 to June 2013. $ETCO_2$ data were collected and documented in a specifically designed resuscitation chart by the attending nurse. Prior training sessions were arranged for the proper use of capnometry and frequency of $ETCO_2$ documentation. All $ETCO_2$ data was collected prospectively while the outcome and demographics were retrieved from the local cardiac arrest registry, which was a database prospectively collecting data of patients of OHCA in Utstein template.

☆ A Spanish translated version of the summary of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2016.02.021.

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http://dx.doi.org/10.1016/j.resuscitation.2016.02.021
0300-9572/

All patients aged 18 years or above who suffered OHCA were included. Exclusion criteria were those patients with traumatic cardiac arrest or postmortem changes, those who decided for Do Not Resuscitate (DNR) before arrival, those who were not resuscitated due to medical futility, those who had regained spontaneous circulation before hospital arrival and those who were not intubated or without proper documentation of $ETCO_2$ value. All patients were resuscitated on scene by pre-hospital personnel according to the BLS protocol. Automated external defibrillators were utilized and defibrillation would be performed if indicated. All ambulances had at least one ambulance crew trained with EMA-2, which implies the second level of emergency medical assistant training. The personnel would be competent to deliver basic life support with bag-valve-mask ventilation and chest compression. In addition, they are able to deliver defibrillation by external defibrillators and use of laryngeal mask airways in eligible cases. After arrival to the hospital, patients were resuscitated according to the ACLS guideline 2010 with endotracheal intubation and high quality chest compressions. End-tidal capnometry was applied immediately after endotracheal intubation. $ETCO_2$ values were obtained and charted every 3 min or where there is a major change of value. A Nellcor™ Microstream model N85 by Medtronic was used to measure the $ETCO_2$ values in the study.

Ethics approval was waived from the local institutional review board. The study was performed according to the ethical principles in the Declaration of Helsinki and the Good Clinical Practice guideline of the International Conference on Harmonization.

Definition

ROSC was defined, for all rhythms, as the restoration of a spontaneous circulation that results in more than an occasional gasp, fleeting palpated pulse or arterial waveform which continued for approximately more than 20 min, in accordance with the Utstein style.[7]

Medical futility was defined as medical condition that any proposed therapy would not improve the patient's clinical condition according to the available data.[8]

A 3-min $ETCO_2$ value was defined as the $ETCO_2$ value 3 min after endotracheal intubation and application of end-tidal capnometry. The $ETCO_2$ value would be considered to be valid if there was steady waveform shown in capnograpy. If the value was not available at exactly 3 min, the earliest valid reading would then be taken. A cut-off of $ETCO_2$ $\leq$10 mmHg was defined as a low $ETCO_2$ value for prognosticating outcome[29] according to previous studies.

Data collection

Variables collected include patients' age, gender, site of arrest, witnessed arrest, bystander cardiopulmonary resuscitation (CPR), initial rhythm in the scene and in emergency department, defibrillation in pre-hospital phase and in emergency department were recorded. Emergency medical response (EMS) time is defined as the time of EMS call to the arrival of pre-hospital personnel to the scene. Arrest to ED time is defined as the time of EMS call to the arrival to the emergency department. EMS response time and arrest to ED time were utilized as surrogates of time to basic life support (BLS) and advanced life support (ALS) respectively. Data was collected in standardized forms of the cardiac arrest registry. Outcome variables were traced by electronic hospital records, including ROSC, survival to hospital admission and survival to hospital discharge.

Statistical analysis

Various variables were compared between the ROSC and no-ROSC group. Categorical data would be presented as frequencies and percentage and analyzed using the chi-square or Fisher's exact test where appropriate. Continuous variables were presented in mean and standard deviation and were compared by independent sample *t*-test when normally distributed. Skewed variables were shown in median and interquartile range and compared with the Mann–Whitney *U* test. Variables that were significant in univariate analysis and/or known OHCA prognosticators from the literature were entered to a logistic regression model to identify predictors of return of spontaneous circulation (ROSC) with confounding control. Model calibration was assessed by the Hosmer and Lemeshow test while model discrimination was assessed by the area under receiver-operating-characteristic curve of the predicted probabilities. Adjusted odds ratios and their confidence intervals were calculated. Diagnostic characteristics including sensitivity, specificity, positive and negative predictive values were calculated for $ETCO_2$ $\leq$10 mmHg predicting death in emergency departments (ED), i.e., no ROSC. Receiver-operating characteristic curve (ROC) was created for $ETCO_2$ predicting ROSC. Area under the curve along with the 95% confidence interval was presented. IBM SPSS version 20 for Windows was utilized for statistical analysis.

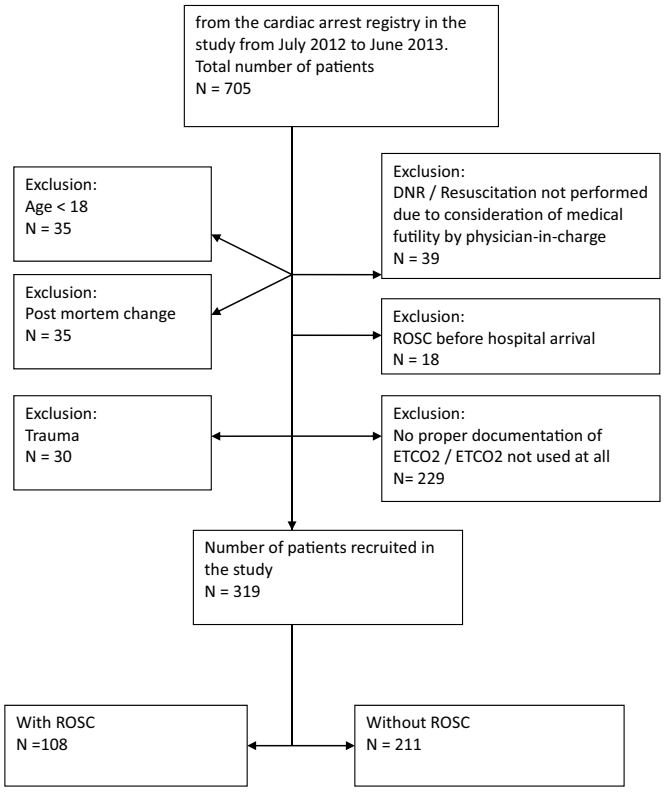

Fig. 1. Patient inclusion in the study.

Results

Seven-hundred and five patients were recorded in the local cardiac arrest registry from July 2012 to June 2013. Fig. 1 shows the selection of patients from the cardiac arrest registry in the study. Three-hundred and nineteen patients of non-traumatic OHCA aged $\geq$18 years old were included in the study. Data was traced from the local cardiac arrest registry. There was no significant difference between the included cohort (N = 319) compared to the excluded cohort (N = 229), in terms of baseline characteristics and outcome (supplemental Table S1).

Table 1 shows the baseline characteristics of patients selected. The mean age of patients was 71 with male slight predominance of