Resuscitation 92 (2015) 77–81

Contents lists available at ScienceDirect

Resuscitation

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

Clinical Paper

Initial end-tidal carbon dioxide as a prognostic indicator for inpatient PEA arrest☆

Alex K. Pearce[a], Daniel P. Davis[b], Anushirvan Minokadeh[c], Rebecca E. Sell[d,*]

[a] Tulane University School of Medicine, New Orleans, LA, United States
[b] Department of Emergency Medicine, UC San Diego, San Diego, CA, United States
[c] Division of Anesthesiology & Critical Care, Department of Anesthesia, UC San Diego, San Diego, CA, United States
[d] Division of Pulmonary & Critical Care, Department of Medicine, UC San Diego, 9300 Campus Point Drive #7381, La Jolla, CA, United States

ARTICLE INFO

Article history:
Received 24 October 2014
Received in revised form 24 February 2015
Accepted 23 April 2015

Keywords:
Cardiopulmonary arrest
Cardiopulmonary resuscitation
Capnography

ABSTRACT

Aim: Investigate the relationship of initial PetCO2 values of patients during inpatient pulseless electrical activity (PEA) cardiopulmonary arrest with return of spontaneous circulation (ROSC) and survival to discharge.
Methods: This study was performed in two urban, academic inpatient hospitals. Patients were enrolled from July 2009 to July 2013. A comprehensive database of all inpatient resuscitative events is maintained at these institutions, including demographic, clinical, and outcomes data. Arrests are stratified by primary etiology of arrest using a priori criteria. Inpatients with PEA arrest for whom recorded PetCO2 was available were included in the analysis. Capnography data obtained after ROSC and/or more than 10 min after initiation of CPR were excluded. Multivariable logistic regression was used to explore the association between initial PetCO2 >20 mmHg and both ROSC and survival-to-discharge.
Results: A total of 50 patients with PEA arrest and pre-ROSC capnography were analyzed. CPR continued an average of 11.8 min after initial PetCO2 was recorded confirming absence of ROSC at time of measurement. Initial PetCO2 was higher in patients with versus without eventual ROSC (25.3 ± 14.4 mmHg versus 13.4 ± 6.9 mmHg, $P = 0.003$). After adjusting for age, gender, and arrest location (ICU versus non-ICU), initial PetCO2 >20 mmHg was associated with increased likelihood of ROSC (adjusted OR 4.8, 95% CI 1.2–19.2, $P = 0.028$). Initial PetCO2 was not significantly associated with survival-to-discharge ($P = 0.251$).
Conclusions: Initial PetCO2 >20 mmHg during CPR was associated with ROSC but not survival-to-discharge among inpatient PEA arrest victims. This analysis is limited by relatively small sample size.
Published by Elsevier Ireland Ltd.

1. Introduction

Despite scientific progress in the field of resuscitation, outcomes following cardiac arrest (CA) remain poor. Over 350,000 people die from out-of-hospital cardiac arrest (OHCA) in the United States yearly and over 200,000 die from in-hospital CA (2013 American Heart Association).

Most studies focus on OHCA, specifically those caused by ventricular fibrillation (VF) or ventricular tachycardia (VT). Although less than one quarter of OHCA, this population has a more uniform etiology and higher chance of survival to discharge making it an ideal study cohort.[1] While defibrillation for VF/VT is essential, it is clear that the quality of cardiopulmonary resuscitation (CPR) rate, depth and compression fraction all contribute to improved outcomes. Capnography is used during CPR as a non-invasive measure of cardiac output. End tidal carbon dioxide (PetCO2) values correlate with coronary perfusion pressure, quality of chest compressions and return of spontaneous circulation (ROSC).[2] In addition, PetCO2 can be used to predict mortality. A PetCO2 value less than 14.3 mmHg (1.9 kPa) after 20 min of CPR for OHCA had a sensitivity, specificity, positive and negative predictive value for mortality of 100%.[3] Grmec et al., also examined the first measured PetCO2 during CPR of OHCA and found that a higher PetCO2 predicted etiology of arrest (VF versus asphyxial).[4] The same group also found that initial PetCO2 predicted survival.[4,5]

Inpatient CA, however, is fundamentally different from OHCA. Patients with inpatient cardiac arrest are typically older, frequently critically ill with sepsis, heart failure or respiratory failure, and have multiple co-morbidities. More than 80% of inpatient CA are typically a bradycardic pulseless electrical activity (PEA) or asystole.[6,7]

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2015.04.025.

* Corresponding author.
E-mail address: rsell@ucsd.edu (R.E. Sell).

http://dx.doi.org/10.1016/j.resuscitation.2015.04.025
0300-9572/Published by Elsevier Ireland Ltd.

Despite arrest location and immediate access to medical care, ROSC and survival rates for in hospital PEA arrest remain low. Peberdy et al., reported a rate of ROSC of 44.7–51.1%, and survival to discharge of 14.7–19.8%, while investigators from the American Heart Association Get with the Guidelines-Resuscitation group reported survival to discharge increased in 2009 to 22.3%.[6,8] In addition to the utility of continuous capnography in ensuring compression quality and indicating ROSC, initial PetCO2 may have utility in guiding resuscitation efforts.

In this study we evaluate the prognostic utility of initial PetCO2 value measured during resuscitation of inpatient PEA arrests to predict ROSC and survival to discharge.

2. Materials and methods

This was a retrospective analysis performed at two urban, academic inpatient facilities in San Diego. This study was approved by the institutional review board (IRB project 131476X). A comprehensive quality improvement database maintaining data on all inpatient resuscitative events is maintained for both facilities. A CA was defined by absence of a palpable pulse, the performance of chest compressions, and/or a defibrillation attempt. For our purposes, return of spontaneous circulation (ROSC) was defined as return of a perfusing rhythm, i.e., sustained pulses, for >1 h. Although traditionally "any ROSC" may be defined as any brief (>30 s) gasp, palpable pulse or arterial wave form, we chose to require a sustained perfusing rhythm to define a single resuscitation event.[9] In both facilities a Code Blue team responds to each CA. The Code Blue team includes a critical care fellow or senior medicine resident, a critical care nurse, a respiratory therapist, a pharmacist, and an emergency medicine attending or anesthesiology senior resident for airway management.

All practitioners that are a part of the UC San Diego Health System undergo Advanced Resuscitation Training (ART) annually. This institutional treatment algorithm emphasizes the unique needs of in-hospital CA. The algorithm utilizes the availability of ECG filtering during compressions, CPR feedback and quantitative capnography. Compressions are begun immediately on recognition of CA. On arrival of the code team, the code RN attaches the defibrillator pads and places a back board under the patient. While ensuring adequate compressions (rate 100 compressions/min, depth >2 inches and good recoil), a mainstream PetCO2 sensor is placed between the oxygen supply and the face mask or endotracheal tube. "See-through CPR" is used to minimize time out of CPR for rhythm analysis, and feedback used to ensure adequate compressions. A breath is supplied by the respiratory therapist and airway physician every 10th compression on recoil. PetCO2 is used to assess quality of compressions, compressor fatigue, and ROSC.

Following each resuscitation event, clinical and demographic data are abstracted from the electronic medical records and quality improvement databases. Compression and capnography data are also exported from defibrillators (Zoll E Series, Zoll Medical Inc., Chelmsford, MA) when available. A multi-disciplinary committee of critical care providers reviews all resuscitation events.

The quality improvement database contains demographic, clinical and outcomes data from all inpatient arrests from 2005 to 2013. All cardiac arrest resuscitation events are categorized by presenting rhythm, asystole/PEA or VF/VT, and by etiology using a priori criteria and using chart review, imaging studies and/or autopsy; separating arrests are categorized into 4 basic pathophysiological processes: respiratory, circulatory, dysrhythmic and neurological.

In this study we identified all patients presenting with PEA rhythm and selected patients with available PetCO2 data. A total of 50 patients with initial PetCO2 values within the first 10 min of CPR and pre-ROSC PetCO2 values were identified for analysis.

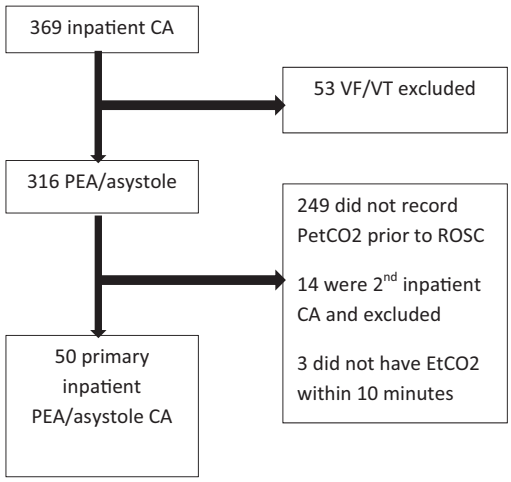

Fig. 1. Characteristics of inpatient CA included during the study period.

The first measured PetCO2 was abstracted from the defibrillator data. Only data from the initial arrest was included for patients with more than one arrest event during the same hospitalization. Arrests that occurred in the emergency department, operating rooms, or in patients with "Do Not Attempt Resuscitation" (DNAR) orders were excluded.

In addition to the primary analysis, two smaller subsets of the sample cohort were further analyzed. One subset included patients for whom initial PetCO2 data was available during the first 3 min and a second subset included patients that had capnography data available during the first minute of CPR only.

3. Statistical analysis

For all statistical analysis SPSS version 21 (SPSS Inc., Armonk, NY) was used. Summary results are presented as number (%) or mean (95% confidence interval). Categorical and dichotomous variables were compared using the Fisher exact test and continuous variables were compared by a 2-tailed Mann–Whitney *U* test. The Shapiro–Wilk test was used to determine normality of distribution.

For the primary sample including patients that had capnography data available during the first 10 min of recorded CPR, multivariable logistic regression was used to quantify the relationship between ROSC and PetCO2. Two PetCO2 cutoff values, PetCO2 >20 mmHg and PetCO2 >10 mmHg, were chosen a priori and evaluated by logistic regression. Both unadjusted and adjusted odds ratios (ORs) for the PetCO2 cutoff values were calculated. In the adjusted model, age, sex and ICU status were selected as covariates based on a priori criteria. The Hosmer–Lemeshow test was used to assess goodness-of-fit. *P*-values less than 0.05 were considered statistically significant.

4. Results

A total of 369 inpatient CA were identified. Of these, only 50 were primary inpatient PEA/asystolic CA with pre-ROSC capnography data available during the first 10 min of CPR (Fig. 1). The cause of arrest was defined by a priori criteria. The causes of PEA arrest were sepsis (21, 42%), respiratory failure (15, 30%), heart failure (5, 10%), pulmonary embolism (3, 6%), hemorrhage (2, 4%), dysrhythmia (2, 4%), hyperkalemia (1, 2%), and following a vagal event (1, 2%). ROSC was attained in 30 (60%) patients and 11 (22%) patients survived to discharge. The average time from onset of CPR to initial PetCO2 measurement was 3.04 min and the average time after the first PetCO2 measurement to ROSC or the end of the code was 11.8 min. Demographic and clinical data are displayed in Table 1.