Resuscitation 85 (2014) 332–335

Contents lists available at ScienceDirect

Resuscitation

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

Clinical Paper

Predicting the lack of ROSC during pre-hospital CPR: Should an end-tidal CO_2 of 1.3 kPa be used as a cut-off value?

Leif Rognås[a,b,c,d,*], Troels Martin Hansen[c,d], Hans Kirkegaard[e], Else Tønnesen[f]

[a] Department of Research and Development, Norwegian Air Ambulance Foundation, P.O. Box 94, 1441 Drøbak, Norway
[b] Pre-hospital Critical Care Team, Department of Anaesthesiology, Viborg Regional Hospital, Heibergs Allé 4, 8800 Viborg, Denmark
[c] Pre-hospital Critical Care Team, Aarhus University Hospital, Oluf Palmes Allé 32, 8200 Aarhus N, Denmark
[d] Department of Pre-hospital Medical Services, Central Denmark Region, Oluf Palmes Allé 34, 8200 Aarhus N, Denmark
[e] Centre for Emergency Medicine Research, Aarhus University Hospital, Trøjborgvej 72-74, Building 30, 8200 Aarhus N, Denmark
[f] Department of Anaesthesiology, Aarhus University Hospital, Nørrebrogade 44, 8000 Aarhus, Denmark

ARTICLE INFO

Article history:
Received 19 September 2013
Received in revised form
24 November 2013
Accepted 7 December 2013

Keywords:
Cardiac arrest
End-tidal CO_2
Pre-hospital critical care
Emergency medical system
Helicopter emergency medical system
Critical decision making

ABSTRACT

Aim: The aim of this study was to investigate if an initial $ETCO_2$ value at or below 1.3 kPa can be used as a cut-off value for whether return of spontaneous circulation during pre-hospital cardio-pulmonary resuscitation is achievable or not.
Materials and methods: We prospectively registered data according to the Utstein-style template for reporting data from pre-hospital advanced airway management from February 1st 2011 to October 31st 2012. Included were consecutive patients at all ages with pre-hospital cardiac arrest treated by eight anaesthesiologist-staffed pre-hospital critical care teams in the Central Denmark Region.
Results: We registered data from 595 cardiac arrest patients; in 60.2% ($n = 358$) of these cases the pre-hospital critical care teams performed pre-hospital advanced airway management beyond bag-mask ventilation. An initial end-tidal CO_2 measurement following pre-hospital advanced airway management were available in 75.7% ($n = 271$) of these 358 cases. We identified 22 patients, who had an initial end-tidal CO_2 at or below 1.3 kPa. Four of these patients achieved return of spontaneous circulation.
Conclusion: Our results indicates that an initial end-tidal CO_2 at or below 1.3 kPa during pre-hospital CPR should not be used as a cut-off value for the achievability of return of spontaneous circulation.

1. Introduction

The European Resuscitation Council Guidelines for Resuscitations recommends the use of waveform capnography for confirmation of tracheal tube placement whenever endotracheal intubation (ETI) is performed during cardio-pulmonary resuscitation (CPR).[1]

Several authors,[2–8] most recently Heradstveit et al.[9] and Qvigstad et al.,[10] have suggested that measuring end-tidal carbon dioxide ($ETCO_2$) may also be useful for optimising CPR quality and as an aid for prognostication during CPR. Kolar et al. from the emergency medical system (EMS) in Maribor, Slovenia found that among 1086 non-traumatic adult cardiac arrest patients (collected during a period of eight years) none of the patients in their study with an initial $ETCO_2$ below 1.33 kPa achieved ROSC.[11] The authors suggest using an $ETCO_2$ of 1.33 kPa as a cut-off value for whether return of spontaneous circulation (ROSC) following pre-hospital cardiac arrest (CA) is achievable. We are not aware of any successful validation of these findings and the knowledge of the prognostic significance of $ETCO_2$ – measurements during pre-hospital CPR remains limited.

1.1. Objectives

The objective of the study was to investigate if an initial $ETCO_2$ value at or below 1.3 kPa can be used as a cut-off value for whether ROSC during pre-hospital CPR is achievable or not.

We hypothesised that in patients with pre-hospital CA, treated according to European Resuscitation Council Guidelines for Resuscitation,[1] an initial $ETCO_2$ at or below 1.3 kPa is a predictor for lack of ROSC and pre-hospital death.

☆ 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.2013.12.009.

* Corresponding author at: Pre-hospital Critical Care Team, Aarhus University Hospital, Oluf Palmes Allé 32, 8200 Aarhus N, Denmark.
E-mail addresses: leifrogn@rm.dk (L. Rognås), troehans@rm.dk (T.M. Hansen), hanskirk@rm.dk (H. Kirkegaard), else.toennesen@aarhus.rm.dk (E. Tønnesen).

0300-9572
http://dx.doi.org/10.1016/j.resuscitation.2013.12.009

2. Methods

2.1. Study design

The data analysed in the present study is part of an observational study[12,13] where we prospectively collected data related to pre-hospital advanced airway management (PHAAM) in accordance with the consensus-based template made by Sollid et al.[14]

2.2. Setting

We investigated the anaesthesiologist-staffed pre-hospital critical care teams in the Central Denmark Region. This region covers a mixed urban and rural area of approximately 13,000 km^2 with a population of 1,270,000, and an overall population density is 97.7 inhabitants per km^2.

The standard EU emergency telephone number (1-1-2) covers all Denmark and there is an Emergency Medical Dispatch Centre in each of the five Danish regions. Emergency Medical Dispatch is criteria based and telephone guided CPR is provided.[15]

The Emergency Medical Service (EMS) in the region is a two-tiered system based on 64 road ambulances staffed by emergency medical technicians (EMTs) supported by ten pre-hospital critical care teams staffed with an anaesthesiologist (with at least 4½ years' experience in anaesthesia) and a specially trained EMT. Rapid response vehicles deploy nine of the pre-hospital critical care teams; the tenth team staffs a Helicopter Emergency Medical Service (HEMS) helicopter.

The pre-hospital critical care teams covered by this study employ approximately 90 anaesthesiologists as part time pre-hospital physicians. All pre-hospital critical care anaesthesiologists in the region primarily work in one of the five regional emergency hospitals or at the university hospital and they all have in-hospital emergency anaesthesia and advanced airway management both in- and outside the operating theatre as part of their daily work. Intensive care is part of the Danish anaesthesiological curriculum.

EMTs and the pre-hospital critical care teams are expected to follow the European Resuscitation Council Guidelines for Resuscitation.[1] The LUCAS® automated chest compression device is available on all the anaesthesiologist-staffed rapid response vehicles as well as on the HEMS. We have described the EMS system in our region in more detail elsewhere.[12,13,16]

We collected data between February 1st 2011 and November 1st 2012.

2.3. Participants

2.3.1. Inclusion criteria

Consecutive pre-hospital cardiac arrest patients of all ages where the pre-hospital critical care anaesthesiologist performed PHAAM beyond bag-mask ventilation (BMV).

2.4. Endpoints and variables

Primary endpoints were: (1) initial $ETCO_2$ after PHAAM during CPR and (2) return of spontaneous circulation.

Secondary endpoints were: (1) Pre-hospital mortality.

We defined initial $ETCO_2$ as the first $ETCO_2$ obtained after PHAAM and return of spontaneous circulation as any period (no time limit) of spontaneous circulation following PHAAM.

We collected all core data proposed in the consensus-based template by Sollid et al. and we defined the variables as in this template.[14]

The indications for performing PHAAM are categorised by Sollid et al.[14] We included patients where the pre-hospital critical care physician had marked "cardiac arrest" as the reason for performing PHAAM.

The pre-hospital critical care teams or the EMTs on the road ambulances measured oxygen saturation, heart rate and blood pressure by using a LifePak 12 monitor (Physio-Control, Redmond, USA). The pre-hospital critical care teams monitored $ETCO_2$ either via the LifePak 12 or via a Nellcor NPB-75 capnograph (Tyco Healthcare Group LP, Pleasanton, USA). None of these devices can display the $ETCO_2$ as 1.33 kPa; it is either 1.3 or 1.4. Therefore, we chose at or below 1.3 kPa as the cut-off value in this study.

The physicians registered the initial $ETCO_2$ as a free-text variable. During data analysis, we labelled the initial $ETCO_2$ as being either under 1.3 kPa, at 1.3 kPa or above 1.3 kPa.

2.5. Data sources and data collection

We collected data from eight of the ten pre-hospital critical care teams, including the HEMS. Due to substantial differences in staffing, caseload, case mix and routines during the study period, only eight of the ten pre-hospital critical care teams provided data for the study.

The anaesthesiologists filled in a registration form (provided as a Supplemental File) containing all the core data recommended by Solid et al.[14] If the patient died on-scene, we reviewed the written pre-hospital charts as well as the entry made in the electronic patient journal for any evidence of temporary ROSC. For patients transported during ongoing CPR, we evaluated the same sources for evidence of temporary ROSC. If there were any doubt, whether the patient achieved ROSC or not we included the patient in the "no ROSC" group during data analysis.

2.6. Bias

To reduce the risk of recall bias and selection bias, the primary investigator reviewed the registration forms on a day-to-day basis. We crosschecked the registration forms with the standard pre-hospital records from the pre-hospital critical care teams to ensure the highest possible data coverage. In cases of missing data or inconsistencies, we asked the attending pre-hospital critical care physician to provide additional details for clarification.

2.7. Study size and statistical methods

In-depth discussions with an expert statistician at Aarhus University resulted in the following:

In theory, it would only take one single patient with a true initial $ETCO_2$ at or below 1.3 kPa and subsequent ROSC for us to have to reject the hypothesis. However, this one case could be due to for instance equipment malfunction and we therefore decided that we would reject the hypothesis if two or more patients with an initial $ETCO_2$ at or below 1.3 kPa achieved ROSC.

Sample size calculations made by the statistician in the statistical software *Stata 12* (*StataCorpLP*) showed that to be able to confirm the hypothesis with a power of at least 80% and a level of significance of 95% we would need to include 100 patients with an $ETCO_2$ of less than 1.3 and no ROSC. In cases of unobtainable missing data, we performed complete case analyses.

2.8. Ethics

No patients had their treatment altered because of the study.

All physicians participated in the study on a voluntary basis – there were no refusals.

The study did not involve any alterations from normal practice and according to Danish law, it did not need the approval of the Regional Ethics Committee, nor did we need the patients' consent to register and publish the data. The Danish Data Protection Agency approved the study (Journal number 2013-41-1462).