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Clinical paper

An assessment of ventilation and perfusion markers in out-of-hospital cardiac arrest patients receiving mechanical CPR with endotracheal or supraglottic airways

Torben K. Becker[a,*], Aric W. Berning[b], Arjun Prabhu[d], Clifton W. Callaway[c], Francis X. Guyette[c], Christian Martin-Gill[c]

[a] Department of Emergency Medicine, University of Florida, PO Box 100186, Gainesville, FL 32610, USA
[b] University of Pittsburgh School of Medicine, 3550 Terrace St, Pittsburgh, PA 15213, USA
[c] Department of Emergency Medicine, University of Pittsburgh, 200 Lothrop St, Pittsburgh, PA 15213, USA
[d] Emergency Medicine, Mt. Sinai Health System, E 101st St, New York, NY 10029, USA

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ABSTRACT

Aim of the study: Mechanical chest compression (MCPR) devices are considered equivalent to manual compressions in patient outcomes in out-of-hospital cardiac arrest (OHCA). However, recent data suggest possible harm in patients with a supraglottic airway device (SGA) during MCPR. The aim of this study was to evaluate differences in direct and indirect markers of ventilation and perfusion in patients with cardiac arrest receiving MCPR and who had their airway managed with an endotracheal tube (ETT) or SGA.

Methods: We retrospectively reviewed Emergency Medical Services (EMS) agencies and emergency department (ED) records over a two-year period. We included patients with OHCA who underwent MCPR and who had an advanced airway placed. The primary outcome was differences in intra-arrest end-tidal carbon dioxide (etCO2) measurements. Secondary outcomes included intra-arrest ventilation rates, rates of prehospital return of spontaneous circulation (ROSC), blood pressure upon prehospital ROSC, and 24-h survival.

Results: Valid data sets were available for 126 patients. Eighty-four (66.7%) had an ETT placed, and 42 (33.3%) had a SGA placed. Twenty-eight (22.6%) achieved prehospital ROSC. Twenty-four-hour survival data were available for 13 (10.3%) of these patients. There were no significant differences in primary or secondary outcomes.

Conclusion: In this retrospective study, we found no evidence of differences in markers of ventilation, perfusion or prehospital ROSC and survival in patients with OHCA who had their airway managed with either an ETT or SGA while receiving MCPR.

Introduction

In recent years, many systems have introduced automated mechanical chest compression (MCPR) devices as part of multimodal efforts to improve the outcomes after cardiac arrest, both in the prehospital and in-hospital setting. Some observational studies found improved survival with MCPR [1]. Subsequent randomized controlled trials (RCT), however, did not detect differences in outcome [2–4]. Nevertheless, given its ability to consistently deliver high-quality chest compressions [5], as well as the potential safety and logistical benefits for performing cardiopulmonary resuscitation (CPR) during prolonged OHCA or during transport, many Emergency Medical Services (EMS) systems continue to use MCPR.

Recent evidence suggests possible harm of MCPR in some patients [6,7]. Of concern is the potential for insufficient ventilation during MCPR when a supraglottic airway device (SGA) is used, as opposed to an endotracheal tube (ETT). Theoretically, high intrathoracic pressures generated by MCPR devices may impede airflow from a SGA into the lungs. In addition, the cumulative effects of closed circuit ventilation and MCPR on intra-thoracic pressure may compromise preload and cardiac output. The large RCTs on MCPR did not report detailed data on airway management strategies or effectiveness of ventilation [8]. In this study, we assessed whether

* Corresponding author at: Department of Critical Care Medicine, 3550 Terrace St, 607 Scaife Hall, Pittsburgh, PA 15261, USA.
E-mail address: tbeckermd@gmail.com (T.K. Becker).

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Table 1
Patient characteristics.

	Groups		
	All Advanced Airways	ETT	SGA
Number of patients (n)	126	84	42
Mean age (years, IQR)	66 (55.25, 77)	69 (57.75,78.25)	62 (54, 71.5)
Male sex (n, %)	81 (64.3%)	56 (66.7%)	25 (59.5%)
Layperson CPR prior to EMS (n, %)	12 (9.5%)	4 (4.8%)	8 (19.0%)
Mean (SD) time between dispatch and CPR (min)	7.8 (6.4)	7.9 (4.2)	7.8 (9.5)
Mean (SD) time between start of MCPR and ROSC (min)	15.0 (8.0)	15.2 (8.0)	14.2 (8.5)
Mean (SD) time between airway placed and ROSC (min)	16.5 (11.0)	16.4 (11.7)	16.8 (9.4)
ROSC achieved (n)	28	22	6
ROSC achieved and hospital data available	13	12	1
Alive at 24 h (n)	5	4	1

Legend: ETT = endotracheal tube; SGA = supraglottic airway device; IQR = interquartile range; SD = standard deviation; CPR = cardiopulmonary resuscitation; EMS = emergency medical services; MCPR = mechanical chest compressions; ROSC = prehospital return of spontaneous circulation.

differences exist in direct and indirect markers of ventilation and perfusion in patients with cardiac arrest receiving MCPR and who had their airway managed with either an ETT or SGA.

Methods

Design

This study was a retrospective review of electronic records from 3 EMS agencies. We reviewed charts from January 1, 2014 to December 31, 2016 for all patients with OHCA who received MCPR. The start date was chosen because MCPR was implemented in 2 of the 3 participating EMS agencies on this date. The third agency implemented MCPR in November 2014.

Setting

The EMS agencies whose records were reviewed are located in the area of Pittsburgh, PA, USA. The mechanical CPR device used was the LUCAS 2 device (Physio-Control, Redmond, WA, USA). The SGA device used was the King LTD airway (Ambu, Copenhagen, Denmark). All agencies also used the Q-CPR device (Koninklijke Philips N.V., Amsterdam, Netherlands), a software/hardware system that records various parameters during resuscitation and that provides real-time feedback to paramedics.

Data selection

We queried emsCharts (emsCharts Inc., Warrendale, PA, USA), a prehospital electronic health record used by the 3 EMS agencies, for all calls entered during the study period with cardiac arrest that received MCPR. From this query, we proceeded to transfer demographic and prehospital care details into a custom research database, including response time, time to initiation of CPR, whether layperson CPR was performed and time to airway device placement; what type of prehospital airway device was placed; whether prehospital return of spontaneous circulation (ROSC) was achieved; and systolic and diastolic blood pressure upon prehospital ROSC. For all patients who had their airway managed with an ETT or SGA, regardless of manual or mechanical ventilation, details regarding the average intra-arrest ventilation rate and end-tidal carbon dioxide (etCO2) readings of up to 20 min (min) and upon prehospital ROSC were obtained from review of Q-CPR system data. For patients who were transported to a hospital within the UPMC system, we reviewed in-hospital charts (PowerChart, Cerner Corporation, North Kansas City, MO, USA) and recorded whether patients achieved ROSC in the ED and whether they were alive at 24 h.

Outcomes

The primary outcome was differences in intra-arrest etCO2 values. As secondary outcomes, we examined 1) intra-arrest ventilation rates, 2) rates of prehospital ROSC 2) blood pressure upon prehospital ROSC, and 4) survival at 24 h.

Data analysis

Because this was an exploratory study, we included all available data after introduction of MCPR devices into the EMS systems, and no sample size calculations were performed. Data were analysed using descriptive and frequentist inference statistics using R version 3.3.1 (R Core Team) [9]. Data were tested for normality with the Shapiro-Francia test. Normally distributed continuous data were reported as means with standard deviations and were analysed using a two-sample *t*-test, whereas non-normally distributed data were reported as medians with interquartile ranges and were analysed using the Wilcoxon rank-sum test. Categorical data were reported as counts and percentages and were analysed using the chi-square test. A p value of less than 0.05 was considered statistically significant using two-sided tests. Binomial logistic regression was assessed for prehospital ROSC, with airway device and bystander CPR as independent variables. Since this analysis was exploratory and all analyses were planned a priori, there was no statistical adjustment for multiple comparisons.

Results

Our search of patients with documented use of MCPR yielded 140 patients. After further review, 12 entries were excluded because no advanced airway was placed during CPR. One case was excluded because it was unclear which airway device was placed. We excluded one additional patient who achieved prehospital ROSC without MCPR being used (miscoded in the electronic record).

The remaining 126 patients comprised the study cohort, of which 84 (66.7%) had an ETT placed, and 42 (33.3%) had SGA placement. Laypersons performed CPR before EMS arrival in 12 (9.5%) patients. Twenty-eight (22.6%) patients achieved prehospital ROSC and in-hospital outcome data were available for 13 (10.3%) prehospital ROSC patients. Of these patients, 5 were alive at 24 h, 4 of whom had an ETT placed, and 1 who had a SGA placed. Detailed characteristics are given in Table 1. Thirty-eight patients were transported with MCPR in progress to a hospital within our system and 6 achieved ROSC while in the ED. Three of the in-hospital ROSC patients were alive at 24 h, all of whom had an endotracheal tube placed in the field. However, it is unclear from the medical