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Clinical paper

First attempt success with continued versus paused chest compressions during cardiac arrest in the emergency department

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Abstract

Aim: Tracheal intubation is associated with interruption in cardiopulmonary resuscitation (CPR). Current knowledge of tracheal intubation during active CPR focuses on the out-of-hospital environment. We aim to describe characteristics of tracheal intubation during active CPR in the emergency department (ED) and determine whether first attempt success was associated with CPR being continued vs paused.

Measurements: We reviewed overhead video from adult ED patients receiving chest compressions at the start of the orotracheal intubation attempt. We recorded procedural detail including method of CPR, whether CPR was continued vs paused, and first attempt intubation success (primary outcome). We performed logistic regression to determine whether continuing CPR was associated with first attempt success.

Results: We reviewed 169 instances of tracheal intubation, including 143 patients with continued CPR and 26 patients with paused CPR. Those with paused CPR were more likely to be receiving manual rather than mechanical chest compressions. Video laryngoscopy and bougie use were common. First attempt success was higher in the continued CPR group (87%, 95% CI 81% to 92%) than the interrupted CPR group (65%, 95% CI 44% to 83%, difference 22% [95% CI 3% to 41%]). The multivariable model demonstrated an adjusted odds ratio of 0.67 (95% CI 0.17 to 2.60) for first attempt intubation success when CPR was interrupted vs continued.

Conclusions: It was common to continue CPR during tracheal intubation, with success comparable to that achieved in patients without cardiac arrest. It is reasonable to attempt tracheal intubation without interrupting CPR, pausing only if necessary.

Keywords: Airway, Cardiac arrest, Cardiopulmonary resuscitation, Airway management

Introduction

Tracheal intubation has long been the gold standard of airway management during cardiac arrest. Tracheal intubation is believed to provide optimal oxygenation and may reduce the risk of aspiration compared to bag-valve mask ventilation and extraglottic devices. While tracheal intubation and extraglottic devices are both utilized during the management of out-of-hospital cardiac arrest, depending on the local emergency medical services protocol, tracheal intubation is very commonly performed in the ED during cardiac arrest.

However, tracheal intubation requires time to perform and commonly causes interruption of chest compressions, unlike use of extraglottic devices and bag mask ventilation.[1] During out-of-hospital cardiac arrest, interruptions during CPR to perform tracheal intubation are common and average 109 seconds per patient.[2] The 2020 American Heart Association guidelines recommend minimizing pauses in chest compressions to maintain a chest compression fraction of >80%.[3] Minimizing interruptions in cardiopulmonary resuscitation (CPR) helps to mitigate negative hemodynamic and neurologic effects and is associated with improved patient outcomes.[4–7]

While the effect of tracheal intubation on chest compression interruption has been studied in the out-of-hospital environment, there are no studies examining intubation practices in the ED during active CPR.[6,8–9] Using video review, we aimed to determine the frequency and duration of interruptions in CPR during the intubation procedure, and compare first attempt success when chest compressions are continuous versus interrupted.

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Materials and methods

Study design and setting

We performed a retrospective, observational study using video review as our primary method of data collection. This study was approved by the local institutional review board. The study was conducted at Hennepin County Medical Center, an urban, academic ED in Minneapolis, MN, USA with an annual census of approximately 100,000 visits. The treating emergency physicians are solely responsible for the decisions regarding airway management and CPR and they perform all tracheal intubations in the ED. Senior emergency medicine residents (postgraduate year 3 and higher) perform the majority of intubations (>85%), with attending supervision; junior residents and attending emergency physicians perform the remainder.

There is no standard protocol for airway management during cardiac arrest. Physicians in our department are experienced with extraglottic device placement in the ED.[10] It is uncommon to pause chest compressions to perform airway management in our ED. It is routine to use mechanical CPR with the Lunds University Cardiac Arrest System (LUCAS™, Stryker, Portage, MI, USA) along with the impedance threshold device (ResQPod™, Zoll, Chesterfield, MA, USA) for cardiac arrests in our ED. More than 90% of our ED intubations are completed with the Storz C-MAC video laryngoscope (Karl Storz, Tuttlingen, Germany), with near-universal use of a standard geometry blade and a bougie.[11,12]

Selection of participants

Using an institutional registry, we identified adult (≥18 years) ED patients with cardiac arrest intubated between January 1, 2012 through December 31, 2017. From this registry, we reviewed the electronic medical record to determine if chest compressions were administered in the ED. If chest compressions were administered, we reviewed videos recorded by cameras mounted above the resuscitation area to determine if orotracheal intubation was performed during chest compressions. We excluded patients who arrived intubated and or those for whom the ED intubation was performed during a period of spontaneous circulation.

We excluded cases if the video was unavailable. For these cases, we reviewed the medical record to determine if intubation was performed in the ED, whether it was performed during cardiac arrest, and the number of intubation attempts. This review was done to ensure that those with videos were not substantially different than those without. Patients with unavailable videos were not included in the main analysis.

Methods of measurement

We performed a structured review of resuscitation videos recorded for each study patient. Critically ill or injured patients receive care in a 4-bay stabilization room. Each bay has 3 ceiling-mounted video cameras activated by motion sensors. Automated software combines the video streams with output from the patient cardiorespiratory monitor, as well as audio recorded during the case. The videos are stored on a secure server and are primarily used for departmental peer review and quality assurance.

A trained clinician investigator viewed all videos to record data on a standardized form using REDCap (Vanderbilt University, Nashville, TN).[13] The staff member was aware of the general nature of the study but was blinded to specific study aims. We recorded patient demographics, cardiac arrest details (e.g. type of arrest, initial rhythm), type of chest compressions (manual versus mechanical), and ED airway management details including method of intubation, intubation timing, whether chest compressions were interrupted for intubation (including the duration of the interruption in seconds), and the procedural outcome of each intubation attempt. Chest compressions (manual or mechanical) were considered interrupted if they were stopped for any reason, including a switch in personnel performing manual chest compressions. Tracheal intubation attempts were classified by whether chest compressions were continued or interrupted during the attempt.

Outcome measures

The primary outcome was first attempt intubation success, defined as successful placement of an endotracheal tube in the trachea during a single laryngoscope insertion in the mouth. First attempt intubation success is associated with fewer peri-intubation complications.[14,15] Successful placement was confirmed by waveform capnography.

Primary data analysis

We present descriptive statistics and compare first attempt success stratified by whether chest compressions were interrupted or not during the intubation attempt.

To determine if clinical variables including CPR interruption during intubation were associated with successful intubation on the first attempt, we constructed a logistic regression model, including no more than one independent variable for every 10 observed outcomes.[16] Variables were selected a priori by consensus of the authors based on clinical experience and plausibility. Covariates included whether CPR was interrupted, body weight, and the method of CPR (mechanical versus manual). We performed multiple imputation with predictive mean matching to estimate missing body weight values (these values were used only in this model). We used Stata (Version 15, College Station, TX) for all analyses.

Results

Study population

Of the 559 patients who received chest compressions in the ED during the study period, 169 (30%) were included in the final analysis. Of the excluded patients, 224 were not intubated in the ED (already intubated out-of-hospital or never intubated), 66 experienced return of spontaneous circulation before the first intubation attempt, and 100 had no resuscitation video available for review. All 100 patients without a saved overhead video were documented as having tracheal intubation performed during cardiac arrest. We were not able to determine if chest compressions were interrupted or the duration of any interruptions. In these patients, first attempt success occurred in 90 of 100 patients (90%). These patients were not included in the main analysis.

Table 1 shows patient characteristics of the analytic cohort. The cause of cardiac arrest was presumed to be cardiac for a majority of patients, and more than 90% experienced cardiac arrest out of the hospital.

Primary results

Of the 169 patients intubated during active CPR, there were 26 (15%) who had chest compressions interrupted during the tracheal intubation attempt and the median duration of these interruptions

Table 1 – Patient Characteristics and hospital outcomes.

Patient characteristic	Chest compressions continued N = 143	Chest compressions paused N = 26
Age, median (IQR) - years	57 (45–66)	56 (44–63)
Male sex	96 (67)	15 (58)
Weight - kg	83 (74–100) [N = 104]	104 (75–117) [N = 17]
Etiology of cardiac arrest		
Presumed cardiac cause	105 (73)	18 (69)
Respiratory	19 (13)	5 (19)
Drug overdose	13 (9)	0
Other	6	3
Location of cardiac arrest		
Out of hospital	131 (92)	25 (96)
In the ED	12 (8)	1 (4)
Initial cardiac rhythm		
Ventricular fibrillation or tachycardia	34 (24)	7 (27)
Asystole	54 (38)	13 (50)
Pulseless electrical activity	50 (35)	6 (23)
Unknown	5 (3)	0
Details for patients with out of hospital cardiac arrest		
Witnessed arrest	75/131 (57)	17/25 (68)
Bystander chest compressions performed	54/131 (41)	15/25 (60)
AED placed before EMS arrival	20/131 (15)	3/25 (12)
AED shocks delivered by EMS	48/131 (37)	4/25 (16)
Return of spontaneous circulation in the ED	54 (38)	8 (31)
Survival to hospital admission	42 (29)	6 (23)
Survival to hospital discharge	9 (6)	0

Values are no. (%) unless otherwise stated.

AED, automated external defibrillator; ED, emergency department; EMS, emergency medical services; IQR, interquartile range.

was 35 seconds (interquartile range [IQR] 21 to 50 seconds). Duration of CPR interruption is shown in Fig. 2. The remaining 143 (85%) received continuous chest compressions during intubation attempts. The median time from ED arrival to the start of the intubation attempt was 6 minutes in both groups. The method (mechanical vs manual) of chest compressions differed between groups: In the interrupted group, 23% of patients were receiving mechanical chest compressions before the tracheal intubation attempt (with the remaining receiving manual chest compressions), compared to 93% of patients in the continuous CPR group receiving mechanical chest compressions. Video laryngoscope and bougie use were common in both groups (Table 2).

Overall, successful intubation on the first attempt occurred in 84% of patients (95% confidence interval [CI] 78% to 89%). First attempt success was higher in the continuous CPR group (87%, 95% CI 81% to 92%) than the interrupted CPR group (65%, 95% CI 44% to 83%) with an absolute difference of 22% (95% CI 3% to 41%). All patients were successfully intubated in the ED. First attempt duration is displayed in Fig. 1.

The logistic regression model demonstrated an adjusted odds ratio of 0.67 (95% CI 0.17 to 2.60) for first attempt intubation success when CPR was interrupted as compared to when CPR was continuous (Table 3).

Other results

In total, there were 27 cases of first attempt intubation failures. The Supplementary Table contains the reason for unsuccessful first attempts and changes made during subsequent successful attempts. Poor laryngeal view (16 patients, 59%) and distorted upper airway anatomy (4 patients, 15%) were the most commonly cited reasons for unsuccessful first attempts.

After an unsuccessful first attempt, chest compressions were interrupted during subsequent attempts in 3/18 (17%) patients in the continuous CPR group and in 6/9 (67%) patients in the interrupted CPR group.

Limitations

There are important limitations to this study. First, there was likely selection bias in determining when to interrupt chest compressions. Although first attempt intubation success was lower when compressions were interrupted, this is likely because this group of patients was more difficult at baseline. There was no association with success after adjusting for body weight and CPR method. Second, there are very likely unmeasured confounding factors from both the patient and the operator. Third, standard geometry video laryngoscope and bougie use were common and these results may not generalize to other intubation strategies during cardiac arrest. Fourth, due to inherent issues with the overhead recording system, 18% of all CPR patients who were intubated were not captured, therefore we were unable to fully explore patient characteristics. However, the data we were able to gather suggests they were similar to the studied cohort.

Fifth, whether first attempt success has an independent association with neurologically intact survival is not fully explored, and we recognize that first attempt success is not a patient-centered outcome. A previous study, however, reported first attempt success was associated with ROSC[17] and an additional out-of-hospital study

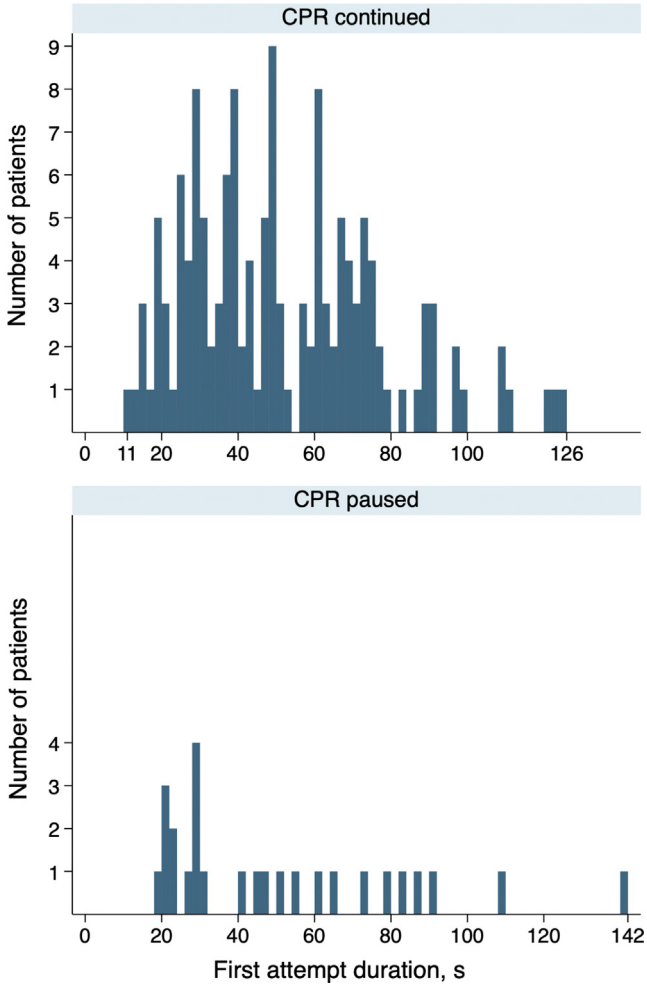

Fig. 1 – First attempt duration. First attempt durations, in seconds, stratified by whether compressions were paused for the first attempt.

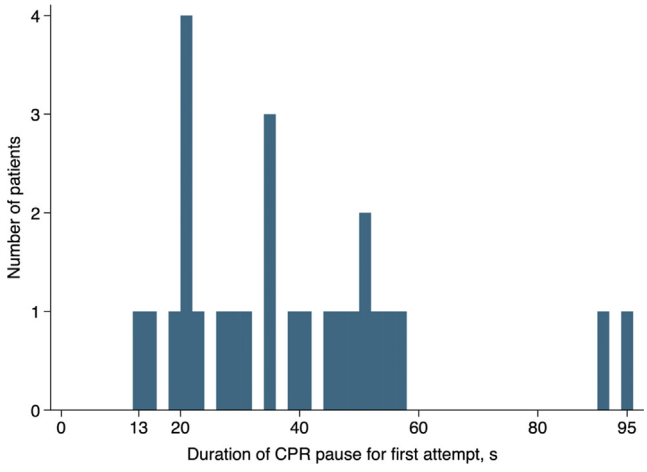

Fig. 2 – Duration of chest compression pause during the first intubation attempt. Duration, in seconds, of the interruption in chest compressions during the first intubation attempt. This figure includes only patients who had chest compressions paused during the first attempt.

demonstrated that fewer endotracheal intubation attempts are associated with more favorable neurological outcome.[18]

Discussion

In this study of ED patients who were intubated while receiving chest compressions for cardiac arrest, it was more common to continue chest compressions than to interrupt them during intubation. First attempt success was 87% when chest compressions were continued, rates that are comparable to recent multicenter data of patients not receiving chest compressions.[12] In our adjusted analysis, however, there was no association between continuing versus interrupting chest compressions and first attempt success. All patients were successfully intubated and it was rare to pause CPR after initial unsuccessful attempts.

There is little published data of airway management in active cardiac arrest in the ED. Most of the published studies of this population are from the out-of-hospital setting.[2,6,8,9] Many out-of-hospital studies demonstrate intubation is associated with significantly more interruptions in CPR than extraglottic airway use.[2,7,19,20] However, Jarman, et al reported no significant difference in duration of CPR interruption on first attempt, comparing tracheal intubation (both video and direct laryngoscopy), bag-valve mask, and extraglottic device placement.[21] Deakin, et al showed no difference in chest compression fraction in endotracheal intubation versus extraglottic device placement.[8] Malinverni et al reported in a subanalysis that endotracheal intubation in cardiac arrest is associated with decreased chest compression fraction during the first cycle only, which is when intubation was taking place, though this early cycle may be the most critical.[22] A study by Donoghue, et al. in pediatric patients demonstrated no difference in first attempt success in interrupting CPR versus not (first attempt success of ETI during CPR 20/32 [63%] compared to 11/27 [41%] when paused [p = 0.09]).[23] Another study by Kim, et al. found no difference in first attempt success between direct and video laryngoscopy, but noted that video was associated with less CPR interruptions.[24] Multiple factors affect the success rate of out-of-hospital endotracheal intubation and first attempt success, including environment, patient selection, intubator training, number of procedures performed annually, routine training, and quality assurance.[20,25,26]

Patients in this series were intubated fairly quickly after arrival, within approximately 6 minutes. It could be argued to favor extraglottic devices in the initial phases of resuscitation due to rapidity of placement. Airway management would then be simpler if performed once the patient had return of spontaneous circulation, provided there is adequate ventilation during chest compressions.

Challenges that complicate the out-of-hospital setting are not fully present in the emergency department, therefore it is understandable that many out-of-hospital providers place an extraglottic airway. Early and continuous high-quality chest compressions remain paramount.[27] Compared to the out-of-hospital setting, ED intubation has the advantages of familiar environment, optimal lighting, and potentially, multiple clinicians skilled at airway management. Though some advocate for continued extraglottic device use in the ED during cardiac arrest, the majority of patients who arrive to the ED with an extraglottic device undergo tracheal intubation.[7] While the ideal airway management strategy is unknown, one study by Wang, et al. suggests early tracheal intubation may result in improved survival.[28].

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Table 2 – Intubation Characteristics.

Intubation characteristic	Chest compressions continued N = 143	Chest compressions interrupted N = 26
Airway management by paramedics on arrival to the ED		
Bag mask ventilation	18	4
Extraglottic device	125	22
Elapsed time between ED arrival and start of intubation, median (IQR) - min	6 (4–9)	6 (3–9)
Type of chest compressions at the time of intubation		
Mechanical	133 (93)	6 (23)
Manual	10 (7)	20 (77)
First intubation attempt details		
Laryngoscope		
Macintosh video laryngoscope	139 (97)	26 (100)
Hyperangulated video laryngoscope	4 (3)	0
Bougie used	117 (82)	23 (88)
First attempt duration, median (IQR) - sec	48 (31–68) [N = 141]	43 (26–72) [N = 26]
First attempt success	125 (87)	17 (65)
Other outcomes		
CPR paused during second intubation attempt	3/18 (17)	6/9 (67)
Overall intubation success	143 (100)	26 (100)

Table 3 – Logistic regression model for the outcome of first attempt success.

Variable	Adjusted odds ratio (95% CI)
CPR paused vs continued	0.67 (0.17 to 2.60)
Weight - kg	1.01 (0.99 to 1.02)
Method of CPR: manual vs mechanical	0.27 (0.07 to 0.95)

Although unadjusted first attempt success was higher when chest compressions were continued, the logistic regression model showed no association between continuing versus pausing CPR and first attempt success. This is likely because the model adjusted for some of the confounding that caused CPR to be interrupted during airway management—perhaps because of obesity, anticipated anatomical difficulties, or body fluids in the mouth. However, it should be noted that the majority of intubations where compressions were interrupted occurred with manual CPR. Our system routinely uses the Lund University Cardiac Arrest System [Physio-Control, Redmond, WA, USA], which fits most adults. However, some adults are too large or small for this device. We speculate that patients receiving manual CPR were too large for the device, making intubation more difficult. Those with CPR continued had an average weight of 83 kg compared to 104 kg for those with paused CPR, supporting this claim.

Conclusions

This study demonstrated that success in patients selected to have continued CPR success was comparable to that achieved in patients without cardiac arrest, though in this study a standard geometry video laryngoscope and bougie were commonly used. Anatomic challenges that make CPR difficult may make intubation difficult, though it seems reasonable to attempt intubation with continued CPR and pause only if necessary.

Previous presentation

No.

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Author contributions

AER, BD, MP, RR, and JNC conceived and designed the study. AER, BD, GH, JS, and JC contributed to data collection and monitoring. BD performed the data analysis. AER, BD drafted the initial manuscript and made final editorial decisions; all authors contributed substantially to its revision.

Conflict of Interest

None.

CRediT Author Contribution statement

Aaron E.Robinson: Conceptualization, Writing: Review and Editing; **Brian E. Driver:** Conceptualization, Writing: Review and Editing; **Matthew E. Prekker:** Conceptualization, Writing: Review and Editing; **Robert F. Reardon:** Conceptualization, Writing: Review and Editing; **Gabriella Horton:** Conceptualization, Writing: Review and Editing; **Jamie L. Stang:** Conceptualization, Writing: Review and Editing; **Jacob D. Collins:** Conceptualization, Writing: Review and Editing; **Jestin N. Carlson:** Conceptualization, Writing: Review and Editing.

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Appendix A. Supplementary data

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