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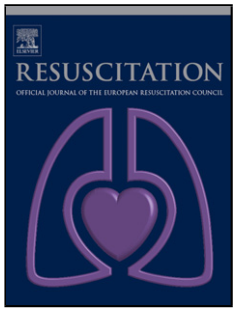

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The Effect of Airway Management on CPR Quality in the Paramedic2 Randomised Controlled Trial

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Abstract

Introduction

Good quality basic life support (BLS) is associated with improved outcome from cardiac arrest. Chest compression fraction (CCF) is a BLS quality indicator, which may be influenced by the type of airway used. We aimed to assess CCF according to the airway strategy in the PARAMEDIC2 study: no advanced airway, supraglottic airway (SGA), tracheal intubation, or a combination of the two. Our hypothesis was that tracheal intubation was associated with a decrease in the CCF compared with alternative airway management strategies.

Methods

PARAMEDIC2 was a multicentre double-blinded placebo-controlled trial of adrenaline vs placebo in out-of-hospital cardiac arrest. Data showing compression rate and ratio from patients recruited by London Ambulance Service (LAS) as part of this study was collated and analysed according to the advanced airway used during the resuscitation attempt.

Results

CPR process data were available from 286/ 2058 (13.9%) of the total patients recruited by LAS. The mean compression rate for the first 5 min of data recording was the same in all groups (P=0.272) and ranged from 104.2 (95%CI of mean: 100.5, 107.8) min^{-1} to 108.0 (95%CI of mean: 105.1, 108.3) min^{-1}. The mean compression fraction was also similar across all groups (P=0.159) and ranged between 74.7% and 78.4%. There was no difference in the compression rates and fractions across the airway management groups, regardless of the duration of CPR.

Conclusion

There was no significant difference in the compression fraction associated with the airway management strategy.

Keywords: Advanced life support; Adrenaline; Epinephrine; Cardiac arrest; Airway; Compression fraction; Outcome

INTRODUCTION

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The optimal strategy for managing the airway during out-of-hospital cardiac arrest (OHCA) has yet to be determined. Three recent randomised clinical trials have compared tracheal intubation with either bag-mask-ventilation[1] or insertion of a supraglottic airway (SGA).[2,3] The cardiac arrest airway management (CAAM) trial showed no difference in favourable neurological outcome between a strategy of early tracheal intubation and delaying intubation until after return of spontaneous circulation.[1] The AIRWAYS-2 trial showed that a strategy of advanced airway management with an i-gel versus tracheal intubation resulted in the same rate of favourable functional outcome at 30 days.[2] The pragmatic airway resuscitation trial[3] trial showed a higher rate of 72-hour survival among patients in the laryngeal tube group compared with the tracheal intubation group.[3]

Different airway management strategies may indirectly influence the proportion of time delivering chest compressions during CPR, thereby influencing outcome from cardiac arrest. Chest compression fraction (proportion of time that chest compressions are delivered) is an independent predictor of survival in ventricular fibrillation/ pulseless ventricular tachycardia (VF/pVT) OHCA[4] although its association with return of spontaneous circulation in non-shockable OHCA has not been demonstrated.[5] Prolonged pauses in chest compressions are also associated with reduced rates of survival, independent of the effect on chest compression fraction.[6] Tracheal intubation attempts during OHCA can be associated with long interruptions in chest compressions and one study has shown that the median duration of interruption associated with the first intubation attempt was 46.5 seconds (IQR 23.5 to 73 seconds).[7] This is a cause of potential harm associated with tracheal intubation in OHCA and it has been proposed that insertion of an SGA is less likely to be associated with prolonged interruption in chest compressions. A secondary analysis of the ROC-PRIMED study documented a slightly higher rate of chest compression fraction (CCF) among patients receiving a SGA (Combitube, laryngeal tube, or laryngeal mask airway) compared with those receiving a tracheal tube.[8] In contrast, another observational study showed no difference in compression fraction among OHCA patients managed with a basic airway strategy, laryngeal tube or tracheal intubation.[9] A secondary analysis of the CAAM trial from one of the participating centres showed that CCF was the same among OHCA patients managed with a bag-mask compared with those managed with early tracheal intubation.[10]

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In a multicentre double-blinded controlled trial of adrenaline versus placebo in out-of-hospital cardiac arrest (PARAMEDIC-2), emergency medical services (EMS) personnel used either a SGA or tracheal intubation as the first advanced airway; in many cases both airways were used.[11] One of the five ambulances services participating in the PARAMEDIC-2 trial, the London Ambulance Service NHS Trust, collected CPR process data, including CCF, from defibrillators. The primary aim of this study was to assess the baseline characteristics and CCF for participants who had received one of four airway strategies: no advanced airway, SGA, tracheal intubation, or a combination of the two, in the PARAMEDIC2 study. Our hypothesis was that tracheal intubation was associated with a decrease in the CCF in comparison with use of alternative airway management strategies.

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METHODS

PARAMEDIC2 trial design and participants

PARAMEDIC2 was a multicentre double-blinded placebo-controlled trial conducted by five National Health Service (NHS) ambulance trusts in the United Kingdom (UK) from December 2014 to October 2017 inclusive.[11] Participants treated for out of hospital cardiac arrest who were not successfully resuscitated by means of defibrillation or CPR, and who met predetermined eligibility criteria were randomly allocated to either adrenaline or saline placebo. Randomisation occurred when trial paramedics opened packs containing prefilled syringes loaded with either ten 1 mg doses of adrenaline or ten doses of 0.9% saline. Trial packs and their contents were identical in appearance and carried a unique identification number. In all other respects identical paramedic resuscitation protocols were followed. The airway management strategy was at the discretion of the trial paramedic, depending on their own preference and experience and based on their resuscitation protocols; in many cases more than one airway device was used. General principles of paramedic airway management involve a stepwise approach, initially commencing with a bag and mask, before progressing to a supraglottic airway and then, only if necessary to achieve adequate ventilation, a tracheal tube. If the patient was randomised to tracheal intubation, then it would be expected that the insertion of an iGel would be omitted in this stepwise approach. Patient notes often did not record, nor did we collect, the reasons for an advanced airway to be changed from an iGel to a tracheal tube or vice versa.

A full description of trial methods has been published previously.[12] Secondary analyses of the trial examining initial rhythm,[13] time to treatment[14] and vascular access route[15] have also been published.

Secondary analysis of airway data

This study used data collected from out-of-hospital resuscitation attempts by one of the five study centres (London Ambulance Service) in the PARAMEDIC2 trial. Training in the PARAMEDIC2 trial protocol was offered to paramedics in only one sector of London and, as participation was voluntary, not all paramedics were eligible to recruit patients into the trial. The number of paramedics trained to enrol was 552.

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The London Ambulance Service collected CPR process data from LIFEPAK 100 and LIFEPAK 15 defibrillators. These defibrillators automatically measure and record the cyclical changes in transthoracic impedance between the defibrillation pads as soon as the defibrillator is turned on. Post-event, this data is downloaded to PhysioControl (now Stryker) CODE-STAT software which analyses the raw impedance data to produce a summary report of the compression rate and fraction, both by minute and by whole episode for each cardiac arrest episode. The compression fraction is defined as the time during which compressions are performed divided by the total time during which resuscitation is being performed. The compression rate is defined as the number of compressions divided by the total time of compression delivered.

Data collected prior to and at the scene of the cardiac arrest include: age, gender, initial rhythm, aetiology, witnessed, bystander CPR, time from emergency call to trial drug administration, time from emergency call to emergency medical services (EMS) personnel arrival, time from EMS personnel arrival to trial drug administration, time on scene, time transported to hospital, survival at scene, and ROSC at any time. Survival data was collected, but not analysed for this study.

CPR data recorded to LIFEPAK 1000 and LIFEPAK 15 defibrillators was collected for analysis where available. All episodes of cardiac arrest were recorded to the device but not all data was downloaded due to limitations with the IT infrastructure.

Ethics approval had been granted for the PARAMEDIC2 study as described. Further approval was not required for anonymised retrospective data analysis.[11]

A previous study has shown that advanced airways are generally inserted within the first 5 min of starting resuscitation.[16] We therefore analysed the first 5 min of the resuscitation attempt to focus specifically on the window during which the airway is managed and minimise subsequent dilution of any effect of CCF that would occur by including the entire cardiac arrest sequence. This initial 5-minute window was a pre-planned subgroup of the overall data.

Statistical analysis

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Baseline characteristics were summarised using frequency and percentage for categorical variables and mean with standard deviation (SD) and median with interquartile range (IQR) for continuous variables. CPR data in the first 5 complete minutes and whole episode are summarised using mean and 95% confidence intervals (CI) as well as median with interquartile range (IQR). Analysis of variance (ANOVA) was used to compare the CPR data across airway management groups. A two-sided $p<0.05$ is considered statistically significant. Death declared at emergency department was assessed using the Fisher exact test (in STATA version 16.0; StataCorp LLC, College Station, TX). All other statistical analyses were conducted using SAS version 9.4 (SAS Institute, Cary NC).

The trial was funded by the Heath Technology Assessment Programme of the National Institute for Health Research. The funders had no role in the trial design, data collection or analysis, or in the writing of this report. The Warwick Clinical Trials Unit undertook data management activities. The trial statisticians assume responsibility for the integrity of the data and its analysis. The NIHR Current Controlled Trials number is ISRCTN73485024.

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RESULTS

CPR process data were available from 286 of 2058 patients, which represents 13.9% of the total patients recruited by the London Ambulance Service. The CONSORT statement (Figure 1) shows patient flow. Patients' baseline characteristics are summarised by airway management strategy in Table 1. Initial aetiology and rate of witnessed cardiac arrest and bystander CPR were significantly different between airway strategy groups. There was a statistical difference in the rate of ROSC across the airway management groups with a decreased rate of ROSC associated with SGA only.

Table 2 shows the summary of CPR data by airway management strategy. The mean compression rate for the first 5 min of data recording was the same in all groups (P=0.272) and ranged from 104.2 (95%CI: 100.5, 107.8) min^{-1} to 108.0 (95%CI: 105.1, 108.3) min^{-1}. The mean compression fraction was also similar across all groups (P=0.159) and ranged between 74.7% (95%CI: 71.1%, 78.2%)) and 78.4% (95%CI: 76.7%, 80.2%). There was no difference in the compression rates and fractions across the airway management groups, regardless of the duration of CPR.

Overall, both the compression rate and fraction were lower for the whole episode than those in the first 5 complete minutes.

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DISCUSSION

In this secondary analysis of the PARAMEDIC-2 trial we have shown no significant difference in the compression fraction associated with the airway management strategy. Compression fractions in all groups were similar to those reported in other recent trials.[17,18]

Our findings are consistent with two other observational studies that showed no association of compression fraction with airway management among OHCA patients.[9,10] An observational study of 339 OHCAs showed no difference in CCF or number of pauses in chest compressions greater than 10 seconds among patients managed with a bag-mask, SGA or tracheal intubation using either direct laryngoscopy or videolaryngoscopy.[9] A secondary analysis of the CAAM trial from one of the participating centres showed that CCF was the same among OHCA patients managed with a bag-mask compared with those managed with early tracheal intubation.[10]

In contrast to our results, a secondary analysis of the ROC-PRIMED study documented a slightly higher rate of chest compression fraction (CCF) among patients receiving a SGA (Combitube, laryngeal tube, or laryngeal mask airway) compared with those receiving a tracheal tube.[8] In a prospective study comparing the laryngeal tube with bag-mask in 82 OHCAs, the CCF was significantly higher in the laryngeal tube group (75% versus 59%; $p<0.01$).[19] Similar findings were also observed during in-hospital cardiac arrest, where advanced airway management (laryngeal mask airway or tracheal tube) improved chest compression fraction compared with bag-mask.[16] The improvement in compression fraction was explained by CPR providers switching from 30:2 compression to ventilation ratio to continuous chest compressions after advanced airway insertion.

The reasons for this disparity are unclear, but relatively small sample sizes resulting in inadequate power for outcome according to airway management strategy, reliance on secondary analyses, and a high degree of bias according to paramedic preference for airway type are all likely to result in significant confounding variables and very low certainty of effect.

Out-of-hospital paramedic airway management during cardiac arrest is a hotly debated topic with proponents for both minimal intervention with a simple bag and mask and those advocating tracheal intubation as the optimal management strategy. This study adds further

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evidence consistent with most studies that have shown relatively little effect of airway strategy on outcome.

Our study has several limitations. Although defined a priori, analysis of compression fraction according to airway type was not the primary intent of the PARAMEDIC2 study. As such, the results should be considered exploratory and interpreted with caution. As with all studies of airway management during cardiac arrests, several confounding variables may potentially bias results. Not only may the type of airway influence outcome, but the reasons for the choice of initial airway, changing the airway or escalating the airway management ladder may in themselves be confounding variables. Although we have analysed outcome according to the advanced airway that was used, the AIRWAYS2 study showed clearly that many patients will receive several different airway devices, incorporating basic and/or advanced skills and this should be taken into consideration when interpreting the results of this study according to the advanced airway that was used. The relatively small sample size from LAS data is also a limitation. We analysed data over the initial 5-min period although our data does not record the time at which the airway was secured using either an i-gel or tracheal tube. Although the aim at a cardiac arrest would be to secure the airway early in the resuscitation attempt, we cannot be certain that all airway interventions are included in this 5 min window and other studies have used a 10 min window. Hospital airway management has been documented as being achieved within a median time to insertion of 145.5 s (86.8,305.3) for tracheal intubation and 126.0 s (40.0,306.0) for LMA insertion;[16] however, the PART trial documented EMS arrival to successful or abandoned airway insertion of 10.6 min in LT group and 13.4 in TT group.[3]

A further limitation may be related to averaging of quality of CPR data over a five-minute period, when any significant delay or interruption tends to occur only during the early stages of CPR, when the airway is being secured. Any interruptions to chest compressions during airway management may also be related to the skill of the individual delivering care, and their skills may also reflect the effective delivery of other aspects of CPR. Mechanical CPR is also associated with improved chest compression fraction,[20] and this was not a variable that was specifically recorded for study patients. Unlike other studies,[16,21] compression fraction was slightly lower when recorded over the entire episode. Whether this represented a decrease in CPR quality or related to measurement error in determining

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the end of a resuscitation attempt is uncertain. Finally, our study included only adults and therefore there is limited generalisability of findings to children and infants.

Conclusion

In this secondary analysis of the PARAMEDIC-2 trial we have shown no significant difference in the compression fraction associated with airway management strategy. There was however a decreased rate of ROSC associated with SGA use only. As with all retrospective secondary analyses, the results should be interpreted in the context of known limitations.

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AUTHOR CONTRIBUTIONS

Author Contributions: Ji, Lall and Gates, had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Deakin, Nolan, Perkins, Ji, Lall,

Acquisition, analysis, or interpretation of data: Perkins, Deakin, Nolan, Ji, Lall, Gates, Quinn, Fothergill, Rosser.

Drafting of the manuscript: Deakin, Nolan, Perkins, Ji, Lall.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: Ji, Lall, Gates.

Obtained funding: Perkins, Nolan, Deakin, Lall, Quinn.

Supervision: Perkins.

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ROLE OF THE FUNDER/SPONSOR

The views expressed are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care. The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

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CONFLICT OF INTEREST DISCLOSURES

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: support from the NIHR for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; GDP, CD, JN, have volunteer roles with the International Liaison Committee on Resuscitation, European (GDP, JN) and UK (GDP, JN, CD) Resuscitation Councils.

DISCLAIMER

The views and opinions expressed in this report are those of the authors and do not necessarily reflect those of the Health Technology Assessment Programme, the NIHR, National Health Service, or the Department of Health and Social Care

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Figure1: CONSORT Flow Diagram

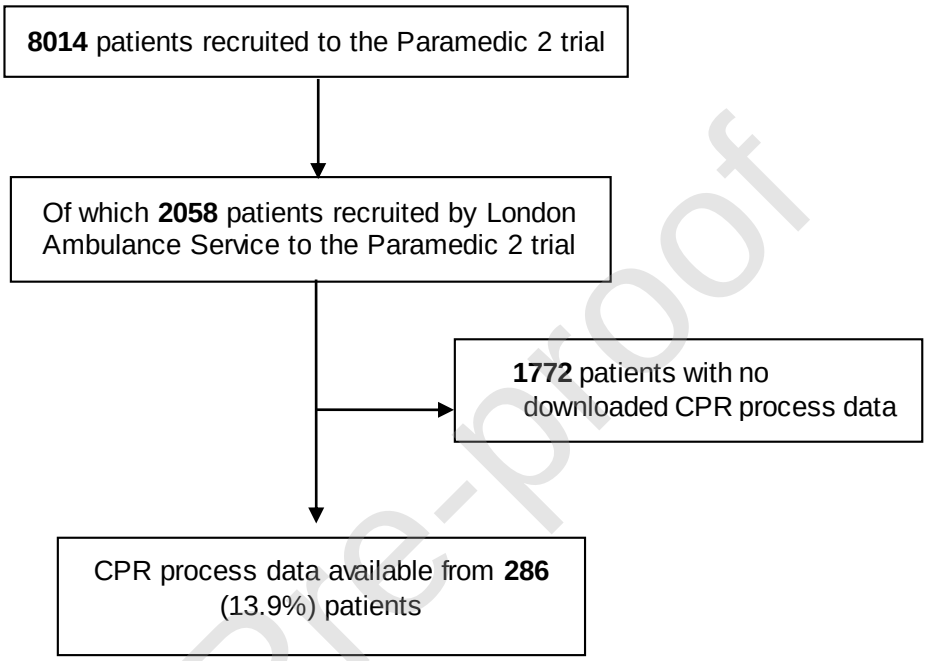

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Table 1: Table 1: Baseline characteristics of patients with CPR data by airway management (n=286)

	SGA only (n=67)	TT only (n=78)	SGA and TT (n=135)	None (n=6)	p value*
Age					
Median (IQR)	61.6 (23.0)	60.9 (26.5)	60.3 (21.5)	38.6 (41.1)	
Missing	0	0	0	0	
Gender					0.367
Female	24 (35.8%)	28 (35.9%)	36 (26.7%)	1 (16.7%)	
Male	43 (64.2%)	50 (64.1%)	99 (73.3%)	5 (83.3%)	
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Initial rhythm					0.065
Shockable rhythm	15 (22.4%)	17 (21.8%)	47 (34.8%)	3 (50.0%)	
VF	14 (20.9%)	14 (17.9%)	40 (29.6%)	3 (50.0%)	
Pulseless VT	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
AED shockable	1 (1.5%)	3 (3.8%)	7 (5.2%)	0 (0.0%)	
Non-shockable rhythm	52 (77.6%)	61 (78.2%)	88 (65.2%)	3 (50.0%)	
Asystole	34 (50.7%)	35 (44.9%)	46 (34.1%)	1 (16.7%)	
PEA	13 (19.4%)	25 (32.1%)	41 (30.4%)	2 (33.3%)	
Bradycardia	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
AED non-shockable	5 (7.5%)	1 (1.3%)	1 (0.7%)	0 (0.0%)	
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Initial aetiology					0.020
Medical	67 (100.0%)	69 (88.5%)	128 (94.8%)	5 (83.3%)	
Traumatic cause	0 (0.0%)	3 (3.8%)	0 (0.0%)	0 (0.0%)	
Drowning	0 (0.0%)	1 (1.3%)	0 (0.0%)	0 (0.0%)	
Drug overdose	0 (0.0%)	3 (3.8%)	1 (0.7%)	0 (0.0%)	
Electrocution	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Asphyxial	0 (0.0%)	2 (2.6%)	6 (4.4%)	1 (16.7%)	
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Occurrence witnessed					0.038

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Unwitnessed	23 (34.3%)	22 (28.2%)	45 (33.3%)	3 (50.0%)	
EMS witnessed	5 (7.5%)	12 (15.4%)	12 (8.9%)	3 (50.0%)	
Bystander witnessed	39 (58.2%)	44 (56.4%)	77 (57.0%)	0 (0.0%)	
Missing	0 (0.0%)	0 (0.0%)	1 (0.7%)	0 (0.0%)	
Bystander commenced CPR					0.048
No bystander CPR	15 (22.4%)	16 (20.5%)	42 (31.1%)	1 (16.7%)	
Bystander CPR	47 (70.1%)	50 (64.1%)	81 (60.0%)	2 (33.3%)	
Not applicable (for EMS witnessed)	5 (7.5%)	12 (15.4%)	12 (8.9%)	3 (50.0%)	
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Intra Venous access					0.584
Yes	48 (71.6%)	58 (74.4%)	102 (75.6%)	6 (100.0%)	
No	19 (28.4%)	20 (25.6%)	33 (24.4%)	0 (0.0%)	
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Intraosseous access					0.276
Yes	26 (38.8%)	29 (37.2%)	45 (33.3%)	0 (0.0%)	
No	41 (61.2%)	49 (62.8%)	90 (66.7%)	6 (100.0%)	
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Administration of Amiodarone					0.196
Yes	9 (13.4%)	12 (15.4%)	33 (24.4%)	1 (16.7%)	
No	58 (86.6%)	66 (84.6%)	102 (75.6%)	5 (83.3%)	
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Declaration of death on scene					0.267
Yes	47 (70.1%)	47 (60.3%)	76 (56.3%)	3 (50.0%)	
No	20 (29.9%)	31 (39.7%)	59 (43.7%)	3 (50.0%)	
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
ROSC at any time					0.027
Yes	15 (22.4%)	31 (39.7%)	57 (42.2%)	3 (50.0%)	
No	52 (77.6%)	47 (60.3%)	78 (57.8%)	3 (50.0%)	
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Declaration of death by emergency department staff					0.106**

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Yes	1 (1.5%)	5 (6.4%)	11 (8.1%)	0 (0.0%)	
No	3 (4.5%)	4 (5.1%)	19 (14.1%)	0 (0.0%)	
Not applicable because not transported	47 (70.1%)	47 (60.3%)	76 (56.3%)	3 (50.0%)	
Not known	16 (23.9%)	22 (28.2%)	29 (21.5%)	3 (50.0%)	
Time from 999 call to At scene (minute)					
Median (IQR)	6.5 (2.8)	6.8 (3.9)	7.0 (5.2)	1.4 (4.9)	0.068
Missing	0	0	0	0	

Note: *, Fisher's exact test and ANOVA were used for categorical and continuous variables, respectively. **, Fisher's exact test was performed using Stata 16.0. SGA supraglottic airway; TT tracheal tube.

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Table 2: Summary of CPR data (n=286)

	SGA only (n=67)	TT only (n=78)	SGA and TT (n=135)	None (n=6)	p value*
Compression rate in the first 5 minutes (per minute)					
Mean (SD)	106.9 (13.3)	104.2 (16.2)	108.0 (12.8)	106.2 (6.1)	0.272
Missing	0	0	0	0	
Compression fraction in the first 5 minutes (per minute)					
Mean (SD)	77.7 (10.9)	74.7 (15.7)	78.4 (10.3)	80.0 (6.9)	0.159
Missing	0	0	0	0	
Compression rate in whole episode (per minute)					
Mean (SD)	104.3 (7.3)	103.7 (6.6)	103.6 (4.6)	104.2 (4.1)	0.886
Missing	0	0	0	0	
Compression fraction in whole episode (per minute)					
Mean (SD)	70.5 (14.8)	69.5 (20.4)	71.4 (14.8)	64.3 (17.8)	0.686
Missing	0	0	0	0	

Note: *, ANOVA was used. SGA supraglottic airway; TT tracheal tube.

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